

**AN ASSESSMENT OF PERFORMANCE
OF WET ATMOSPHERIC DEPOSITION SAMPLERS**

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CONVERSION FACTORS

For the reader who may prefer to use inch-pound units rather than the SI metric units in this report, the following conversion factors may be used:

Multiply metric units	By	To obtain inch-pound units
kilometer (km)	0.6214	mile
liter (L)	1.057	quart
milliliter (mL)	0.0338	ounce, fluid
microliter (μ L)	0.0000338	ounce, fluid
micrometer (μ m)	0.00003957	inch
millimeter (mm)	0.03957	inch
meter (m)	39.37	inch
Water-quality terms and abbreviations used in this report:		
Microsiemens per centimeter at 25 degrees Celsius (μ S/cm at 25°C)		
kilo-ohms (K Ω)		

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ABSTRACT

The variability in performance of seven wet/dry atmospheric deposition samplers was compared for 1 year. Samples were collected weekly, weighed, and analyzed for pH, specific conductance, and common ionic chemical constituents. Data on the duration of each sampler opening were recorded using a microdatalogger. Differences in the results between samplers were assessed based on the manufacturer of the sampler, spatial variability, and sampler siting criteria violations.

The cumulative frequency distributions of the duration of opening of the Viking¹ and Geotech 650 samplers were significantly different than the cumulative frequency distributions for Aerochem Metrics 301 samplers. The deposition² of analytes was also significantly different ($\alpha = 0.05$) for these two samplers because of the difference in collection efficiency. An Aerochem Metrics 301 sampler, located approximately 4 km southwest of the primary sampling site, exhibited the same deposition of analytes and sample volume as the sampler at the primary sampling site. Several of the criteria used in siting samplers for the National Atmospheric Deposition Program/National Trends Network were purposely compromised to determine the validity of such siting criteria. This study showed that objects should be excluded within a 45° cone of the sampler and also that objects of sufficient bulk to disturb wind patterns should be excluded within 5 meters of the sampler.

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¹. The use of brand, trade, and company names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey nor by the U.S. Army.

². Deposition is the product of the concentration of the analyte times the volume of the sample.

INTRODUCTION

History

One of the earliest uses of automatic precipitation samplers was the design by Volchock and Graveson(1976). Since that time other designs have been promulgated. The Aerochem Metrics 301 (Aerochem Metrics Co. Bushnell, Florida) and the Geotech 650 (Leonard Mold and Die Co. Denver, Colorado) are fashioned after the Volchock sampler. The Aerochem Metrics 301 was chosen by the National Atmospheric Deposition Program (NADP), organized in 1977 to determine spatial and temporal trends in atmospheric precipitation, to be the sampler to be used in the network (Bigelow 1982, Cowling 1978). In 1982, the National Trends Network (NTN) adopted the same sampler. Several studies (Bogen and others, 1980; DePena and others, 1980; Galloway and Likens, 1976; Goodison, 1980; Schroder and others, 1985) have been designed to determine the collection efficiency of various samplers. Graham and others (Graham and others, 1987; Graham and others, 1988; Graham and Obal, 1988) have shown that the sensor design affects the successful operation of samplers. They also showed that a small but statistically significant difference exists between samplers that are located as much as 35 meters apart.

Many siting criteria have been applied when locations are selected for precipitation samplers. One set is that which was applied when the National Trends Network was established (Robertson and Wilson 1985). The checklist for compliance of sites with siting criteria that was used during site visits by Robertson and others (1982) and is described in appendix A.

Objectives of Study

The specific objectives of the study were:

1. To study the performance of non-standard NADP/NTN atmospheric deposition samplers. Performance of the Viking and Geotech 650 samplers were compared to the Aerochem Metrics 301 atmospheric deposition sampler (the standard sampler for the NADP/NTN).
2. To study the small distance spatial variability of sample weight and chemistry of wet atmospheric deposition. Two samplers were located approximately 4 km apart. It was hypothesized that small-scale differences in amount of precipitation and precipitation chemistry might be observed over the study area.
3. To study the validity of the criteria used in siting precipitation samplers. Several of the criteria were specifically compromised so as to be able to ascertain if the criteria were valid in the establishment of monitoring sites.

Purpose and Scope of Report

The purpose of the report is to describe the results of a one year effort of wet only atmospheric deposition amount and precipitation

chemistry. The data were analyzed to determine causes in the differences in the performance of the samplers used in the study. Three specific data analyses will be presented:

a. The performance of non-standard NADP/NTN atmospheric deposition samplers, (a Viking and a Geotech 650) was compared with the standard NADP/NTN (Aerochem Metrics 301) atmospheric deposition sampler.

b. The comparison of precipitation amount and precipitation chemistry of two Aerochem Metrics 301 atmospheric deposition samplers located about 4 km apart.

c. Three of the samplers were located in such a manner that several of the siting criteria of the NADP/NTN were not met (appendix A). Specific criteria that were not met were:

1. "Objects with sufficient mass to deflect the wind (with the exception of Alter windshields) over 1 meter high will not be located within 5 meters of the sampler." (Number 5 in appendix A)

2. "No object or structure shall project onto the sampler or rain gauge with an angle greater than 45 degrees from the horizontal (30 degrees is considered optimal, but 45 degrees is the highest angle acceptable). Therefore the distance from the sampler to the object must be at least equal to the height of the object (preferably twice the height of the object). Pay particular attention to the anemometer towers and overhead wires." (Number 9 in appendix A)

3. "Frequent moving sources of pollution, such as air, ground or water traffic or the medium on which they traverse (e.g. runway, taxiway, road, tracks, or navigable river) within 100 meters of the sampler. The local road net around the site is of particular concern." (Number 12 in appendix A)

The data analyses include the application of the 2-way analysis of variance (ANOVA) of a randomized block design and the subsequent use of the nonparametric Friedman test to ascertain differences existing between different types of atmospheric deposition samplers. The data analysis includes all samplers used in the study; any differences which are noted in the data analyses will be discussed in light of the objectives previously stated.

Additionally, the analysis of data from the recorded times of opening and closing of the sampler will be included. Effect upon monitoring programs which use atmospheric deposition samplers also will be discussed.

Description of the Study Site

The monitoring site where six of the samplers were sited is located at the US Military Academy at West Point, New York (fig. 1). The site is also a part of the NADP/NTN network and is identified as site number 335141, WEST POINT (NY99). The site is partially surrounded by a swamp (fig. 1). The soil at the site is gravel fill. The topographic relief in the vicinity of the site is relatively low. The site is located next to a flowing stream that is the outflow of a moderate sized watershed. The seventh sampler was located near a lake located approximately 4 km southwest of the primary sampling site. The latitudes, longitudes, and elevations of each sampler are given in table 1. Details of the sampling site are given in previous communication (Graham and others, 1987).

Table 1.-- Location of samplers and related study objectives [Study objectives: (a) sampler manufacturer; (b) spatial variability; (c) siting criteria. Samplers A-1, A-2, A-3, G-4, A-5 and V-7 were colocated at National Atmospheric Deposition Program/National Trends Network site NY99; sampler A-6 was located 4 kilometers southwest of site NY 99.]

Sampler	Latitude	Longitude	Elevation (Meters)	Objective Tested
A-1	41°21'04"	74°2'57"	203	c
A-2	41°21'04"	74°2'58"	203	c
A-3	41°21'04"	74°2'59"	203	Control
G-4	41°21'04"	74°3'01"	203	a
A-5	41°21'04"	74°2'56"	203	b,c
A-6	41°19'31"	74°5'31"	296	b
V-7	41°21'04"	74°3'00"	203	a

DATA COLLECTION AND SAMPLE PREPARATION PROCEDURES

Seven wet atmospheric deposition samplers were used in the study. The samplers were dispersed in an approximately linear fashion (fig. 1) except for the sampler (A-6) located near the inflow to a lake approximately 4 km southwest of the primary sampling site (NY 99). Five of the samplers were Aerochem Metrics model 301 precipitation samplers (samplers marked A-1, A-2, A-3, A-5 on figure 1 and A-6 4 km southwest of the primary sampling site); a sixth sampler was an unmodified Leonard Mold and Die GeoTech 650 sampler (marked G-4 on figure 1) and the seventh sampler was manufactured by the Viking Company (Salem, Virginia) (marked V-7 on figure 1.) The sensitivity of each precipitation sensor was measured by changing the setting of a decade resistance box shunted across the sensor grid until the sensor just activated the sampler motor. The position of the lid on the sampler was monitored by checking the voltage at the event pen output terminal strip on each sampler. The voltage was measured each minute by a Campbell (Campbell Scientific Inc. Logan, Utah) model CR-7 micrologger.

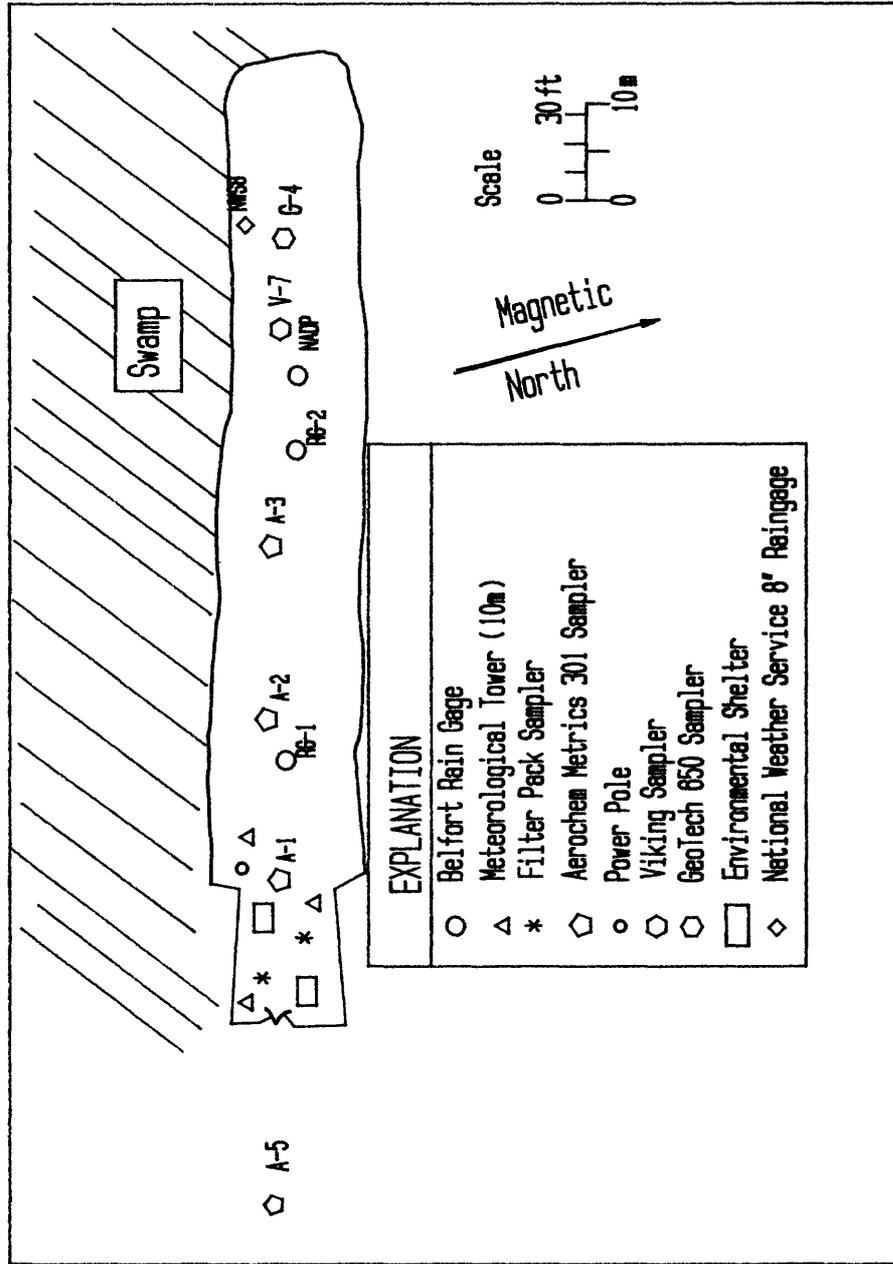


Figure 1.-- Schematic of sampling site and spatial relation of samplers.

A set of voltage values was recorded only if the voltage of any one of the samplers indicated a change of lid position, that is, the lid went from covering the dry bucket to covering the wet bucket or vice versa. A threshold of 8 volts was used to indicate that a change of lid position had occurred. The voltage when the lid is covering the wet bucket (indicating that it is not raining) was near zero. A small offset of 0.2 volts was added to the value read by the microdatalogger because some of the voltages were occasionally slightly negative. The value of the voltage when the lid was covering the dry bucket was in the range from 11 to 13 volts for the Aerochem Metric 301 samplers and from 17 to 18 volts for the V-7 sampler. The opening and closing record of the sampler located 4 km southwest of the primary sampling site was not recorded because of the distance from the microdatalogger.

Sample buckets were changed each Tuesday at approximately 0900 hours local time (Eastern Standard Time or Eastern Daylight as appropriate to the time of year). The sample collection vessels were white high-density polyethylene (HDPE) buckets of approximately 10-liter volume. Lids were placed on buckets prior to removal from the sampler. After removal of the bucket from the sampler, the bucket and lid were placed in a plastic bag for transport to the laboratory. The under-side of the foam-lined and plastic-sealed sampler lid and the lip of the dry bucket were washed weekly with a laboratory tissue soaked in deionized water and dried with a laboratory tissue. The technician wore surgeon's gloves during the changing of all sample buckets. All buckets and lids had been previously scrubbed with a plastic bristle brush and deionized water, then rinsed three times with deionized water and allowed to air dry. Buckets and lids were weighed empty then placed in individual plastic bags for storage and transport to the field site. The sample collection vessels and contents were weighed upon return to the laboratory.

The mass of precipitation in each collection vessel was recorded and converted to equivalent mm of precipitation for comparison to the amount recorded by the NADP rain gage readings at the site. Three Belfort model 5-780 weighing/recording rain gages and one Weathermeasure model P511-E tipping bucket rain gage measured and recorded the amount of precipitation which fell. The amount of precipitation collected in the rain gage marked NADP on figure 1 was used as the standard to which the amount of precipitation collected in each sampler was compared. The signal from the tipping bucket rain gage was also recorded by the Campbell CR-7 data logger. Also, the amount of precipitation in a National Weather Service standard 8-inch rain gage, located at the site, was measured and recorded daily.

After the buckets were weighed, a sample aliquot was removed and the pH and conductance of the precipitation in each bucket were determined on the unfiltered aliquot. pH was determined by placing 4 mL of sample in a 4-mL plastic cup. An Orion 701 pH meter with a Beckman 13013 pH probe, calibrated by the NADP/NTN protocol (Bigelow 1982), was used for the analysis. A Barnstead model PM70CB specific conductance meter with a Yellow Springs Instrument 5301 specific conductance probe, calibrated according to the NADP/NTN protocol (Bigelow 1982), was used in the inverted

mode to determine the specific conductance of each sample. Treatment of the samples in the laboratory consisted of withdrawing three 50-mL aliquots of sample and filtering each aliquot through a 0.45- μ m ACRODISK filter into a 125-mL high density polyethylene plastic bottle. The filter was prerinsed with a 5-mL aliquot of deionized water followed by a 20-mL aliquot of the sample. Two aliquots were left untreated, and the third was preserved with 20 μ L of American Chemical Society reagent grade nitric acid. The three bottles were then sealed and placed in a small, labeled plastic bag. Split samples of sampler A-2 were submitted each week to the laboratory as blind samples. In addition to these quality-control samples, aliquots of deionized water, which had been placed in clean buckets and allowed to set for 24 hours also were submitted on a routine basis to ensure cleanliness of buckets. All small plastic bags were then placed in a large plastic bag in an insulated mailer. Ice was added to maintain temperature at 4°C during shipment.

Samples were mailed to the U.S. Geological Survey analytical laboratory in Arvada, Colorado for analysis. The laboratory determined calcium, magnesium, potassium, and sodium by atomic absorption spectrophotometry. Colorimetric methods were used to determine chloride, nitrate plus nitrite, ammonium, sulfate, and ortho-phosphate. The laboratory determined pH and specific conductance potentiometrically (Fishman and Friedman 1985). This same reference also establishes the expected analytical precision for each of the analytes.

DATA COLLECTION RESULTS

Tables B-1 through B-8 in appendix B represent the results of the chemical analyses conducted on each sample by the U.S. Geological Survey. Missing values in the tables are indicated by -----; whereas table entries that are blank indicate that no precipitation or insufficient precipitation was available for analysis that week. These tables include concentrations of sulfate, ammonium (as ammonium), nitrate plus nitrite (as nitrate), chloride, sodium, potassium, calcium, magnesium, field (determined at U.S. Military Academy) and laboratory (determined at U.S. Geological Survey) pH, and field and laboratory determined specific conductance. Also included in these tables are the weight of each sample and the collection efficiency of sampler collection for the sample period. The efficiency of collection, expressed as a percentage, was calculated by dividing the equivalent mm of precipitation (sample weight x .014732) collected in the sampler by the depth of precipitation, in mm, determined from rain gage data and expressed as a percentage. The rain gage (a Belfort model 5-780 weighing rain gage) that was used for calculation is labelled NADP in figure 1. Table B-9 in appendix B gives the amount of precipitation for each rain gage in equivalent mm of water. Also included in this table are the precipitation amounts as determined from a National Weather Service 8-inch standard rain gage (fig. 1). Tables C-1 through C-13 in appendix C show percentile summaries of the ion concentrations and sample weights.

Measurements of precipitation weight by sampler were taken over a period of 50 weeks from January 1986 through December 1986. The relation of collection week (x-axis of all plots) to the date of collection is shown in table C-14 in appendix C.

The maximum resistances required to open the sampler and the surface temperatures¹ of the sensors used in the study are shown in table 2. The surface temperatures were measured at the top, middle and bottom of the sensor grid. Temperature measurements were made after the temperature stabilized.

DISCUSSION OF RESULTS

Overall Statistical Evaluations

Evaluation of the Results of the Split Analyses

As described earlier, a split of the sample collected in sampler A-2 was submitted to the U.S. Geological Survey laboratory for quality control purposes for evaluation of the degree of variance that might be expected in analytical results. The results of paired t-tests to evaluate whether a difference existed between the original sample and the split are given in table 3. The hypothesis tested was that the mean of the difference [(A-2)-(split A-2)] was zero. The hypothesis could not be rejected for any of the analytes for a confidence interval of 99 percent; however, for potassium, the paired t-test indicated a difference at the 95 percent confidence interval. Additionally, a paired t-test was also conducted to detect differences between the pH determined at the U.S. Geological Survey laboratory and the pH determined at the U.S. Military Academy laboratory. The test was conducted both on the pH and on the hydrogen ion concentration values. No differences were detected for the 99 percent or 95 percent confidence interval.

Data Editing and Estimation

Before the aptness of a statistical model could be investigated, the recorded data had to be edited. There were 6 measurement periods where no precipitation was recorded. Within the remaining 44 weekly periods, there were occasions where data values were missing. This occurred during the weeks when specific samplers were inoperative because of mechanical malfunction or a sample was inadvertently spilled. Weeks that had values missing for one or more parameters were not eliminated because the remainder of the information contained in the data was useful. The missing values were estimated using a weighted average procedure (Hicks, 1973). The weighting procedure is a minimization of the sum of squares and takes into account both the relation to other samplers and the relation of the sampler to itself. The number of missing data values for each of the variables is shown in table 4. The number of missing data values is for the block (that is 7 samplers and 44 weeks) not for an individual sampler. No more than 3 data values were estimated for any given sampler.

1. The sensors upon activation by precipitation are heated to decrease the amount of time which must pass before the sensor detects an end of storm.

Table 2.-- Measurements of surface temperatures and resistances of the sensors [Temperature in degrees Celsius; Resistance in ohms x 10³]

Sampler	Temperature			Resistance
	Top	Middle	Bottom	
A-1	40.6	65.0	40.6	70
A-2	55.0	71.1	43.9	70
A-3	35.0	51.7	52.2	70 (Jan-Mar)
A-3	48.3	57.8	40.6	96 (Apr-Dec)
G-4	50.6	51.7	57.8	>999
A-5	39.4	49.4	42.8	60
A-6	51.1	70.0	50.6	71
V-7	67.8	72.2	64.4	240

Table 3.-- Evaluation of results of paired t-test on laboratory analysis of split sample from Sampler A-2 [t_{test} = test t-statistic; t_{table} = t-value from the tabulated t-distribution; conf = confidence; Yes = significant difference at α significance level]

Analyte	Number of samples	t_{test}	t_{table} ($\alpha=0.05$)	t_{table} ($\alpha=0.01$)	95% Conf interval	99% Conf Interval
Calcium	40	1.55	2.021	2.704	No	No
Chloride	39	-0.018	-2.022	-2.706	No	No
Laboratory						
Conductance	41	-1.764	-2.020	-2.703	No	No
Potassium	39	-2.527	-2.022	-2.706	Yes	No
Laboratory						
pH	41	1.865	2.020	2.703	No	No
Laboratory						
[H ⁺]	41	-1.971	-2.020	-2.703	No	No
Magnesium	40	0.003	2.021	2.704	No	No
Sodium	41	-1.013	-2.020	-2.703	No	No
Ammonium	41	-0.006	-2.020	-2.703	No	No
Nitrate	41	-0.072	-2.020	-2.703	No	No
Sulfate	40	1.306	2.021	2.704	No	No

Table 4.-- Number of data values missing from data base [Values were estimated for each of the missing data values.]

Analyte or variable	Number of missing data values	Analyte or variable	Number of missing data values
Calcium	11	Chloride	15
Collection Efficiency	3	Field Conductance	13
Field pH	12	Laboratory Conductance	11
Laboratory pH	15	Sodium	11
Magnesium	13	Nitrate	14
Ammonium	14	Sample Weight	3
Sulfate	19		

It should be noted that the estimation procedure will tend to make rejection of the null hypothesis slightly more favored than if the missing values were not included. The reason for this is that as the number of observations increases, the corresponding F-Statistic to which test statistics are compared decreases. As the F-statistic decreases, a smaller test statistic could lead to an easier rejection of the null hypothesis.

Appropriateness of Analysis of Variance Model

Use of the parametric analysis of variance (ANOVA) to statistically determine if the samplers performed identically was shown to be improper as the validity of the assumptions of the two-way ANOVA using randomized complete block design were not valid. One such assumption is that the computed random error terms must be normally distributed, with a mean of zero and a constant variance. Examination of the plot of normalized residuals as a function of predicted sample weight (fig. 2) indicated a marked heteroscedasticity at predicted sample weights beyond 1,500 grams. Plots for the remainder of the analytes are shown in appendix D. A plot of the error terms (residuals) as a function of the normalized error terms (fig. 3) indicated a significant departure from the normality assumption for sample weight. For the normality assumption to be valid, the plot in Figure 3 should be described by a straight line rather than the sigmoidal curve that is seen. Plots of the residuals and the normalized residuals for the other analytes are shown in appendix E. The plots of residuals as a function of normalized residuals and plots of the normalized residuals as a function of predicted sample weights for the remainder of the analytes show the marked deviation from the assumptions for the two-way Analysis of Variance.

For these reasons, use of the parametric two-way Analysis of Variance randomized complete block as the model for analysis was deemed inappropriate and a nonparametric approach, the Friedman Test, was chosen.

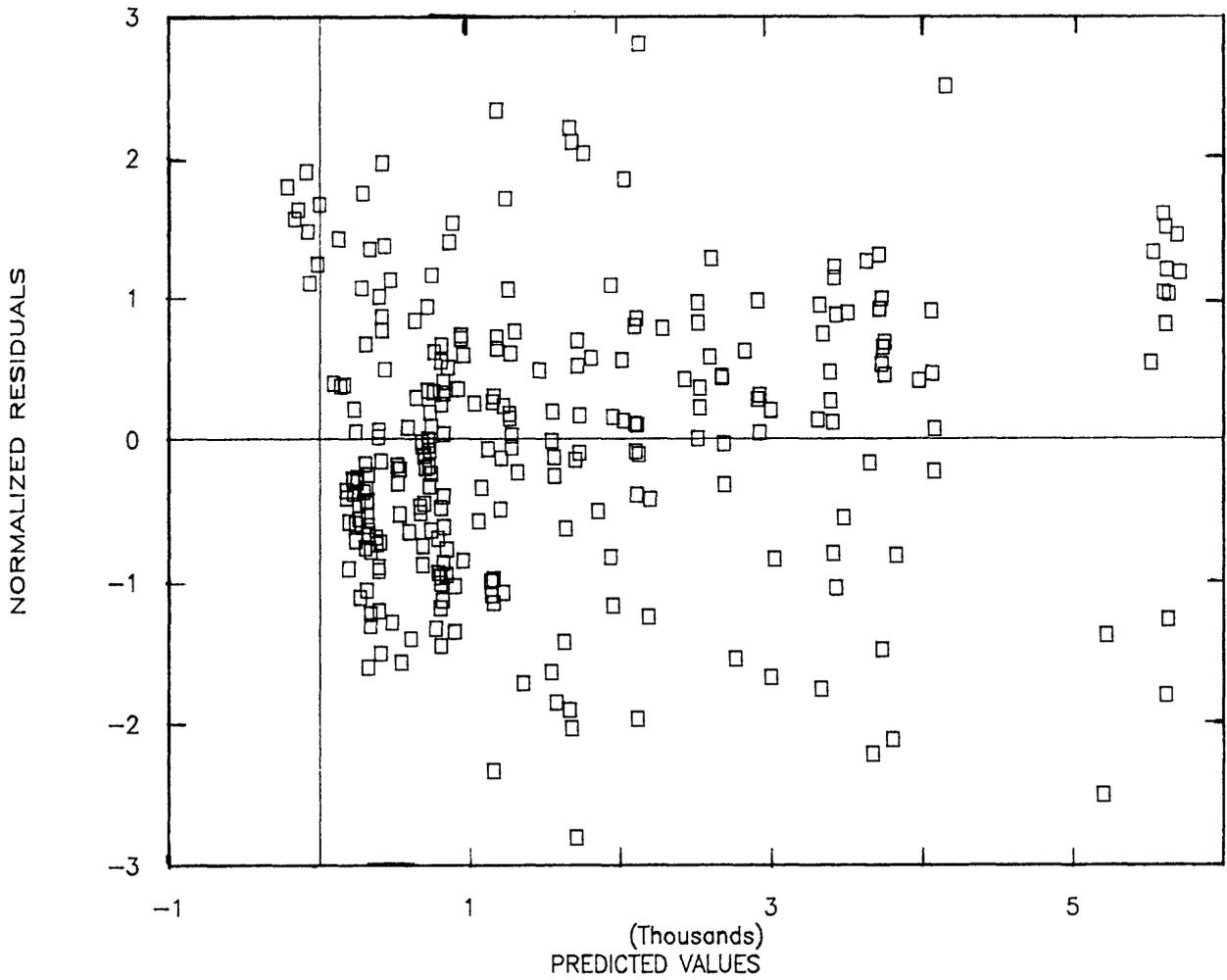


Figure 2.-- Normalized residuals of the predicted sample weights as a function of predicted sample weights [Used to test for constancy of variance. Data collected January - December 1986.]

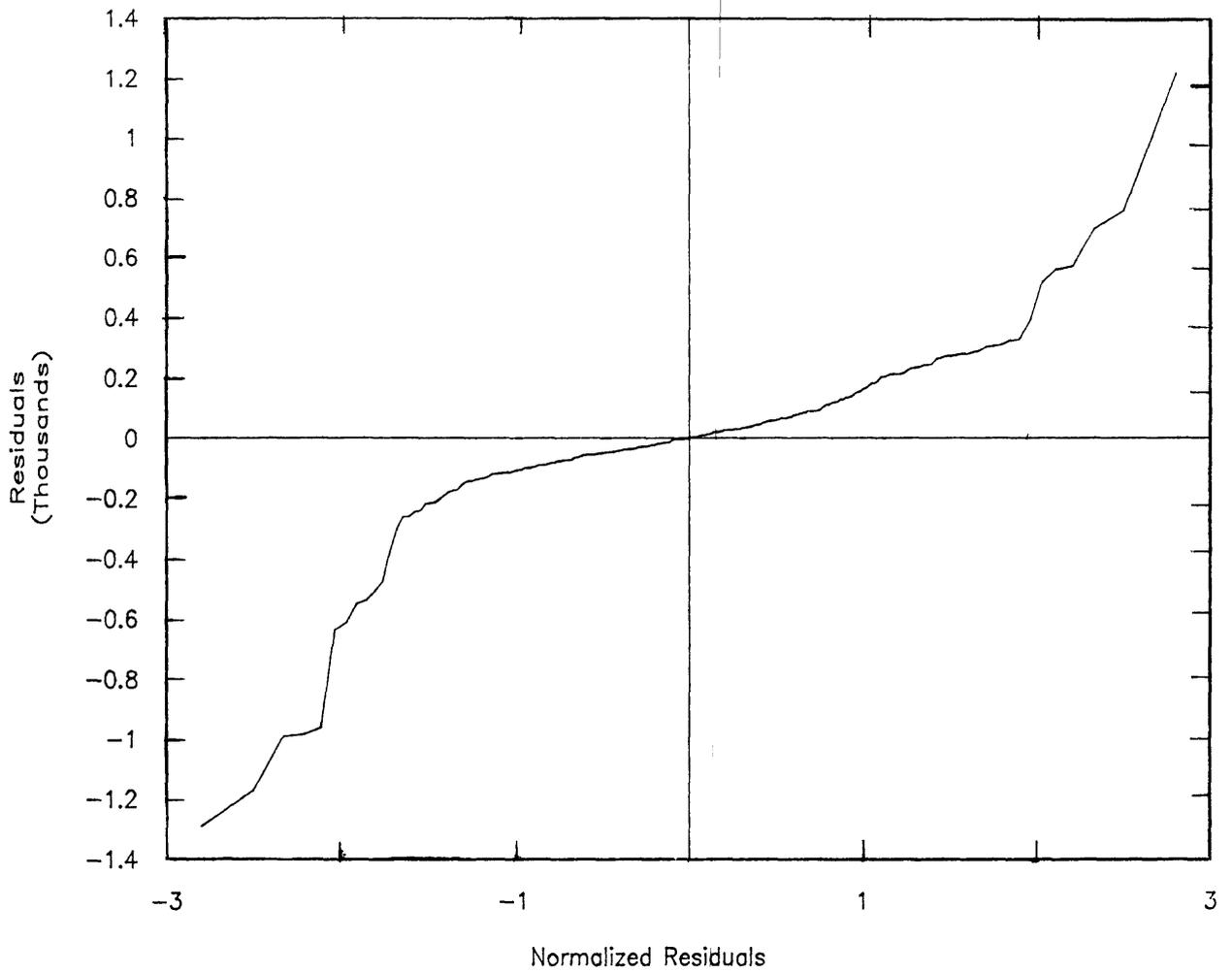


Figure 3.-- Error terms (residuals) as a function of normalized residuals for the determination of normality of residuals.

The Friedman Test (Conover, 1980) is a nonparametric test that can be used with block designs in which the underlying assumptions are not as restrictive as an ANOVA procedure. The technique is based on the ranks of the observations within each block (week). The assumptions pertaining to this test are:

1. The results within one block (week) do not influence the results within the other blocks (weeks).
2. Within each block (week), the observations may be ranked according to some criteria of interest.

The hypotheses to be tested are:

H_0 :The samplers (treatments) have identical effects
 H_1 :At least one of the samplers (treatments) tends to yield larger observed values than at least one other sampler (treatment).

To conduct the test, the observations (X_{ij}) for each variable (sample weight, [Cl-], [SO₄], etc) for each sampler within each week were assigned a rank (R_{ij}); with the smallest sample weight given a rank of 1, the second smallest a rank of 2, and so forth. The quantities necessary to test the hypothesis are:

$$R_j = \sum_i R(X_{ij}), \quad (2)$$

$$A_2 = \sum_i \sum_j R_{ij}^2, \quad (3)$$

$$B_2 = \frac{1}{k} \sum_j R_j^2, \quad (4)$$

where: $i=1,2,\dots,b$ the number of degrees of freedom in the weeks;
 $j=1,2,\dots,k$ the number of degrees of freedom in the samplers;
 $R(X_{ij})$ is the rank of the sampler according to the sample weight for the j th week;
 R_{ij} is the rank of the j th sampler in the i th week;
 R_j is the sum of the ranks over the weeks for the j th sampler.

The test statistic, T_2 , is defined as:

$$T_2 = \frac{(b-1) \left[B_2 - \frac{b \times k \times (k+1)^2}{4} \right]}{A_2 - B_2}, \quad (5)$$

where A_2 is defined in equation (3), B_2 is defined in equation (4), and b and k are as described above.

The decision rule is to reject the null hypothesis if:

$$T_2 > F_{\alpha} \text{ with } (k-1), (b-1) \times (k-1) \text{ degrees of freedom.}$$

Test of Sampler Performance

All seven samplers were considered in the initial hypothesis test. The results of the ranking procedure of the Friedman test as applied to sample weight are:

$$A_2 = 5319 \quad (6)$$

$$B_2 = 4747.3 \quad (7)$$

$$T_2 = 31.77 \quad (8)$$

In general, the table F-values in this report will be reported to worst case the acceptance or rejection of hypotheses. Thus, if the number of degrees of freedom for the numerator and the denominator are $(b-1)$ and $[(b-1) \times (k-1)]$ and the degrees of freedom for the denominator, $[(b-1) \times (k-1)]$, is greater than the largest table value (usually 200), the F-value will be reported for $(b-1)$ and 200 degrees of freedom. It is recognized that the actual F-value will be smaller than this value and should lie in the range of degrees of freedom from 200 to infinity.

The corresponding F-values against which T_2 must be compared are 3.137 ($\alpha=0.01$) and 2.310 ($\alpha=0.05$). The hypothesis of equal sample weights of all samplers must be rejected. It can be concluded that there is a tendency for some samplers to record larger values than others. It should be noted that the data in the tables in Appendix B for the percent collection efficiency of each sampler seem to indicate that a small overall negative bias (that is, the amount of precipitation collected by the sampler is less than the amount of precipitation collected by the rain gage) is exhibited by each sampler, regardless of the manufacturer. However, the tables also show that all of the samplers have an average collection efficiency of over 90 percent. This is in contrast to the efficiencies reported in a similar study (Graham and others, 1987) in which the average collection efficiencies were approximately 86 percent. The main difference between the two studies being the sensors. Unfortunately, little more can be said about the comparison between the two studies since they were performed in different years under very different meteorological conditions.

Pairwise Comparisons

The Friedman Test also allows pairwise comparison when the null hypothesis is rejected. A significant pairwise difference between samplers i and j is indicated if:

$$| R_i - R_j | > t_{\alpha/2} \left[\frac{2 b (A_2 - B_2)}{(b-1)(k-1)} \right]^{\frac{1}{2}} \quad (9)$$

where: $t_{\alpha/2}$ is Student's t value for a significance level of $\alpha/2$ with $(b-1) \times (k-1)$ degrees of freedom,

R_i and R_j are the sampler ranks summed over the weeks as noted previously, and

A_2 and B_2 as defined in equations 3 and 4.

In the examination of all seven samplers, the comparison value for pairwise differences in sample weight is 28.55. A value in the rank difference greater than the comparison value indicates a significant difference in the two samplers. The rank differences for all pairs of samplers for sample weight comparisons are listed at table 5.

Variability of Rainfall Amount-- Rain gages

The amount of precipitation collected in each rain gage each week for the study period was also subjected to the Friedman test. Five rain gages were included in the data analysis. The amounts of precipitation collected by each rain gage are given in table B-9 of appendix B. The results of the Friedman test for the precipitation amounts are given in table 6. It is significant that no difference in general is seen for the rain gages across the study area including the rain gage (RG-6) 4 km southwest. This implies that the amount and distribution of precipitation is statistically the same across the study area. The one rain gage that is statistically different is RG-1 which had an Alter windshield installed. The sum of ranks for the rain gages indicate that RG-1 ranked the highest which is indicative that it generally collected more precipitation. Any differences which are noted in the amounts of precipitation collected in the samplers are because of differences of behavior of the samplers and not due to variations in the amount of precipitation. This must be tempered, of course, with the realization that on individual weeks, the amount of precipitation collected by the different rain gages may be very different; note, for example, the weeks of 21-28 January; 15-22 April; 22-29 April; 22-29 July where as much as 6.3 mm differences in the amount were obtained.

Table 5.-- Summary of results for the sum of rank differences indicated by the Friedman test for --- sample weight [Data collected from 14 January 1986 - 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T₂= 31.772; F-value (α = 0.01) 3.344; F-value (α = 0.05) 2.364. Significant difference value= 28.55. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	55.00*	85.50*	51.50*	95.50*	100.50*	47.50*
A-2		30.50*	106.50*	40.50*	45.50*	7.50
A-3			137.00*	10.00	15.00	38.00*
G-4				147.00*	152.00*	99.00*
A-5					5.00	48.00*
A-6						53.00*

The next logical question to ask is whether the amount of precipitation collected by the rain gages and the samplers is different. The Friedman analysis for this question indicates that no statistical difference exists between samplers A-3, A-5, A-6 and the NADP rain gage. The NADP rain gage was chosen as the comparison rain gage because all of the rain gages were shown to be equivalent. It, also, is situated about the center of the study site located at West Point. The sample weight data that was used in this analysis was for those samplers that compared favorably with each other as shown in table 6.

Table 6.-- Summary of results for the sum of rank differences indicated by the Friedman test for --- Rain gage comparison [Data collected from 14 January 1986-30 December 1986. All rain gages included in comparison. Number of rows = 46; number of columns = 5. T₂ = 5.478; F-statistic (α = 0.01) 3.428; F-statistic (α = 0.05) 2.428. Significant difference value= 28.72. * indicates significant difference.]

	Rain gage			
	RG-1	RG-2	RG-6	NWS8
NADP	30.50*	22.00	12.50	28.50
RG-1		52.50*	43.00*	59.00*
RG-2			9.50	6.50
RG-6				16.00

Variability of Wet Atmospheric Deposition

Chemistry Differences

Each of the sets of concentrations of analytes that were determined by the U.S. Geological Survey laboratory in Arvada were subjected to the Friedman test as described above. The Friedman test variables calculated for each of the analytes are shown in table 7. This table also indicates whether all of the samplers performed equivalently. As indicated in table 7, the Friedman test showed a significant difference in concentration for all but two analytes (field pH and potassium concentration) at the $\alpha=0.01$ level of significance and showed a difference for all analytes at the $\alpha=0.05$ level of significance. The pairwise differences from the Friedman test applied to the analyte concentration are given in tables J-1 to J-12 of appendix F. No table is shown for the Friedman test applied to collection efficiency since collection efficiency is but a linear transformation of the sample weight.

One of the weaknesses of the Friedman test is the inability to assign a magnitude for the difference in performance between samplers. Two attempts to quantify that magnitude were made. The set of data for an analyte and for a sampler (for example $[Ca^{++}]$ and sampler A-2) was sorted to be able to determine the percentile (10, 25, 50, 75, 90) values. The values corresponding to the percentile were then plotted as a function of the percentile for each sampler as shown in figures 4-16. These figures show generally that the V-7 and the Geotech 650 have lower pH's at the higher percentiles, but lower concentrations for most of the analytes. The agreement between all of the samplers is good at lower percentiles, but at the higher percentiles a significant amount of variation is seen.

The second attempt to quantify the magnitude of the statistically significant differences between the performance of samplers was the following. The variance in performance between samplers can be explained on the basis of several factors such as siting differences, spatial variability, analytical differences in laboratory analyses, differences in operational characteristics of the sampler, or functional differences between the samplers. As an estimate of the error expected from the laboratory analysis, the magnitude of the difference between the concentration of the analyte as determined for sampler A-2 and the concentration of the analyte as determined for the duplicate analysis of A-2 will be used. The remainder of the variance between samplers should be explained as operational or functional or siting differences between the samplers. The volume weighted average concentrations as given in table 8 were calculated using the following formula:

$$\overline{[A]} = \frac{\sum_i [A]_i \times \text{Volume}_i}{\sum_i \text{Volume}_i} \quad (10)$$

Table 7.-- Summary results of statistical analysis using the Friedman test for concentration (and sample weight) chemical analytical results [Results are for the statistical analysis of all samplers except the duplicate analysis of A-2.]

Analyte or property	A ₂ (1)	B ₂ (1)	T ₂ (1)	F _{table} (2) α=0.01	Reject equa Performance(3) at α=0.01	F _{table} (2) α=0.05	Reject Equa Performance(3) at α=0.05
[Ca++]	4901	4228.5	4.52	3.139	Y	2.311	Y
[Cl-]	4891	4142.3	5.15	3.141	Y	2.312	Y
Field Specific							
conductance	5256	4380.6	5.26	3.137	Y	2.310	Y
Field pH	4798	4290.3	2.50	3.137	N	2.310	Y
[K+]	5053	4376.3	6.58	3.137	Y	2.310	Y
Lab Specific							
Conductance	5408	4517.6	6.38	3.135	Y	2.310	Y
Lab pH	4931	4330.2	4.56	3.137	Y	2.310	Y
[Mg++]	4691	4223.9	6.15	3.139	Y	2.311	Y
[NH4+]	5222	4344.1	3.71	3.137	Y	2.310	Y
[Na+]	5176	4324.1	2.95	3.137	N	2.310	Y
[NO3-]	5222	4351.4	4.05	3.137	Y	2.310	Y
[SO4=]	5076	4357.4	10.68	3.139	Y	2.311	Y
Sample Weight	5319	4747.3	31.77	3.137	Y	2.310	Y
Collection Efficiency	5319	4755.3	32.75	3.137	Y	2.310	Y

1. A₂, B₂ and T₂ are the numbers calculated for the Friedman test.
2. F_{table} is the F-value to which T₂ is compared.
3. Equal performance is rejected when hypothesis H₀ is rejected. Alternatively, at least one sampler pair has a significant pairwise difference.

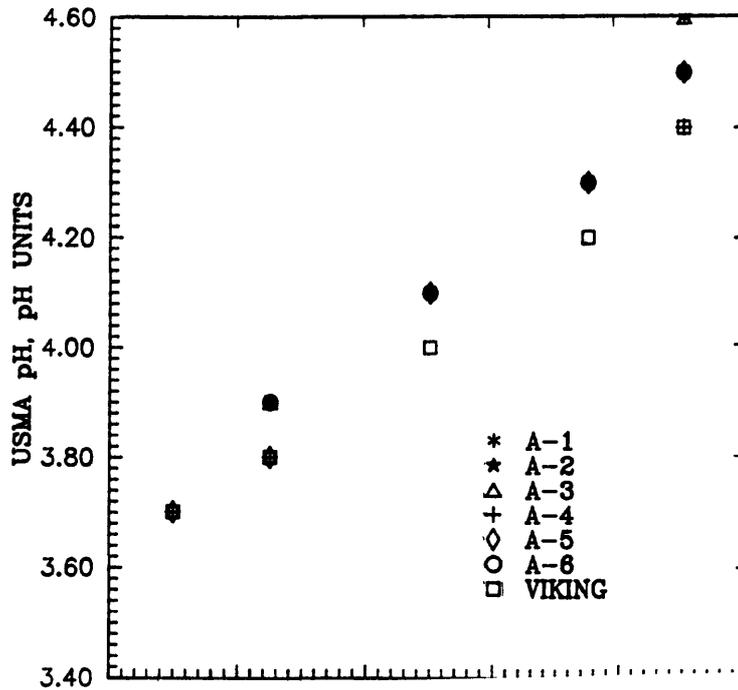


Figure 4.-- Percentile comparison of the pH, determined by the U.S. Military Academy. [Samples collected 14 January 1986 - 11 November 1986.]

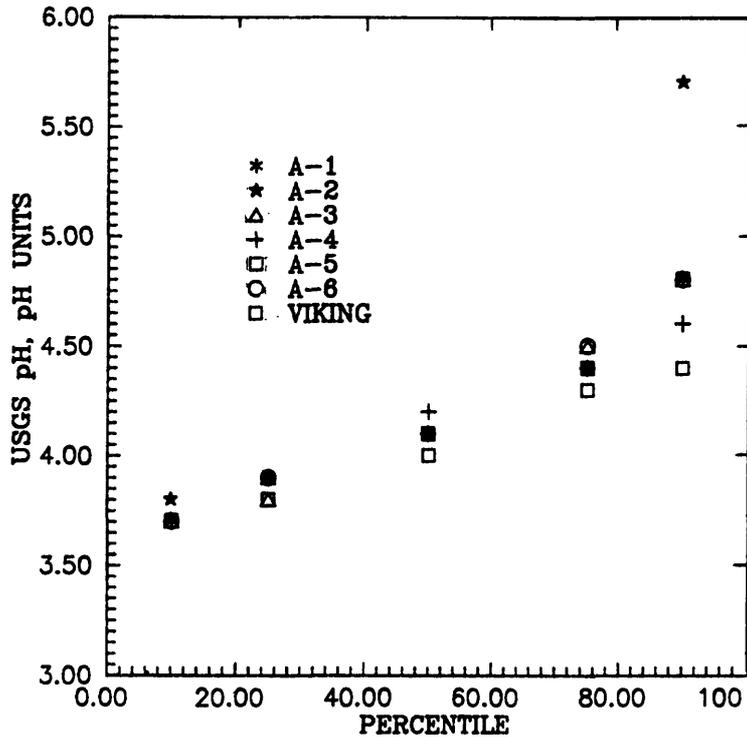


Figure 5.-- Percentile comparison of pH, determined by U.S. Geological Survey. [Samples collected 14 January 1986 - 11 November 1986.]

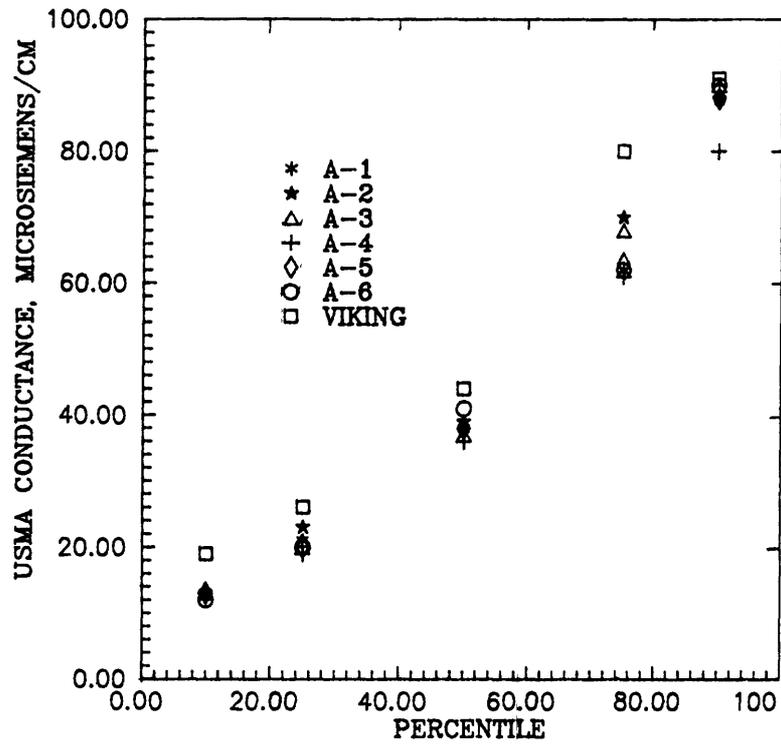


Figure 6.-- Percentile comparison of Conductance determined by U.S. Military Academy [Samples collected 14 January 1986 - 11 November 1986.]

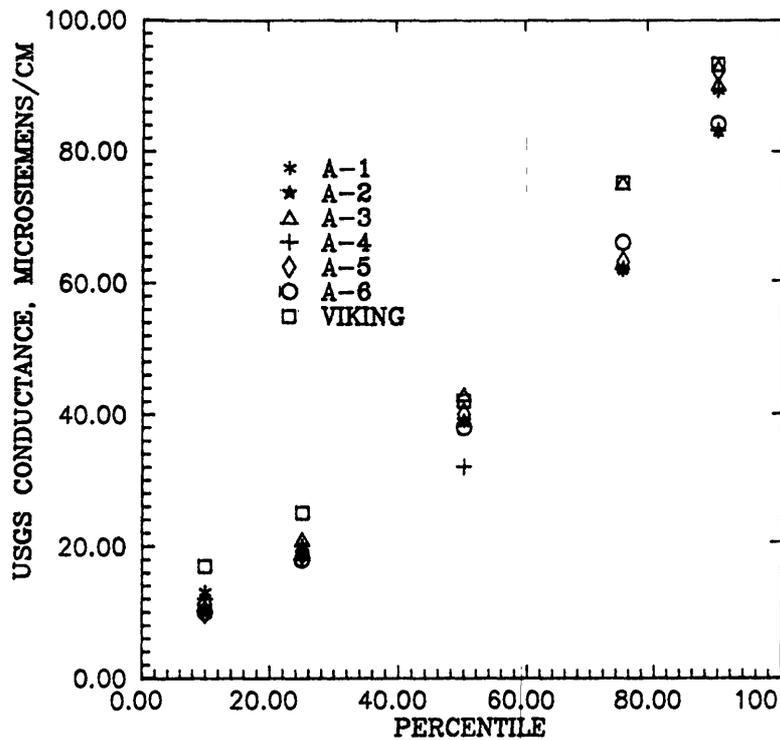


Figure 7.-- Percentile comparison of Conductance determined by U.S. Geological Survey. [Samples collected 14 January 1986 - 11 November 1986.]

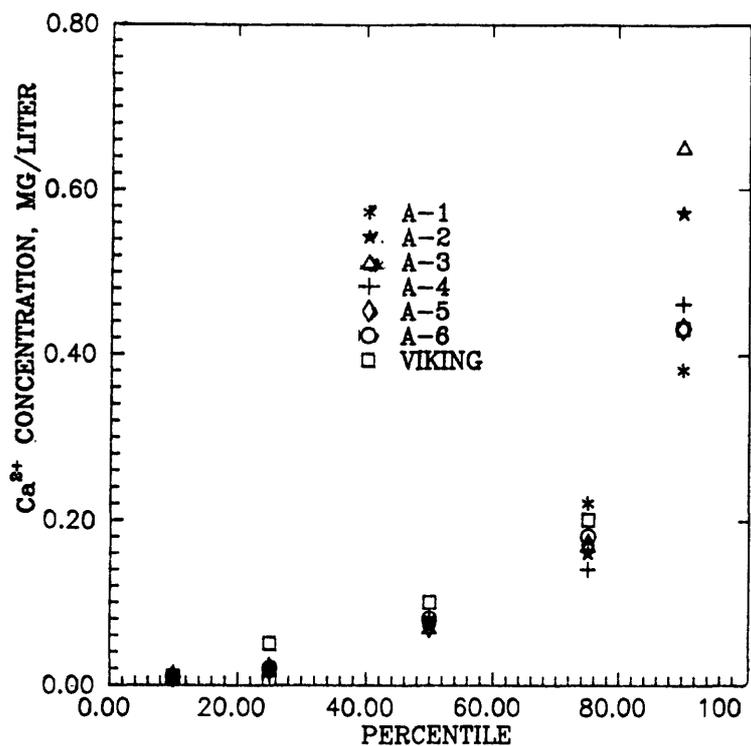


Figure 8.-- Percentile comparison of the concentration of calcium ion. [Samples collected 14 January 1986 - 11 November 1986.]

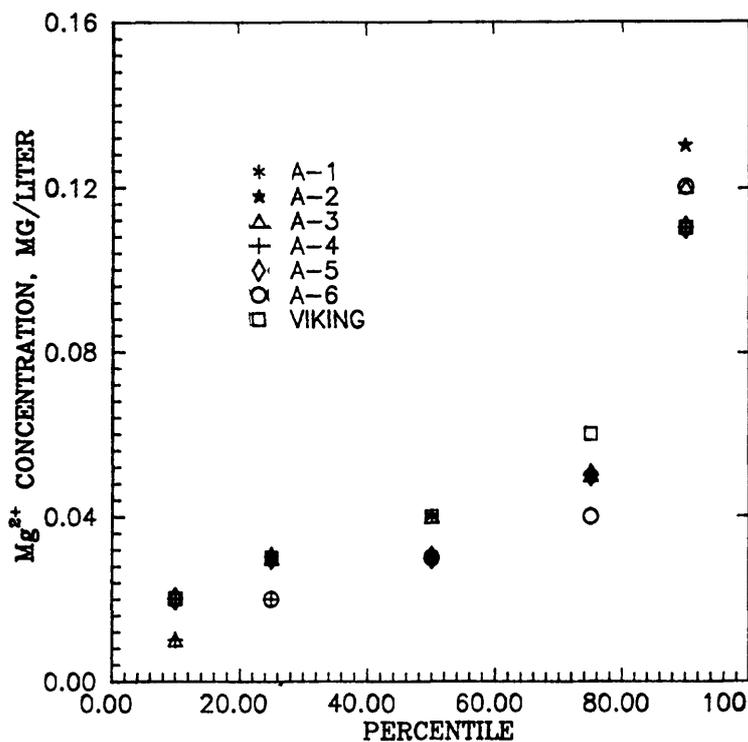


Figure 9.-- Percentile comparison of the concentration of magnesium ion. [Samples collected 14 January 1986 - 11 November 1986.]

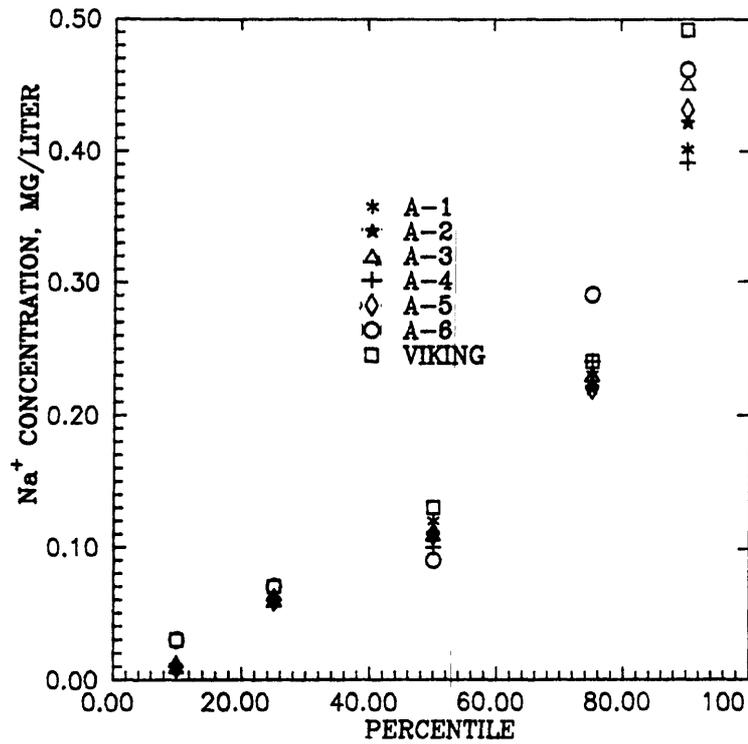


Figure 10.-- Percentile comparison of the concentration of sodium ion. [Samples collected 14 January 1986 - 11 November 1986.]

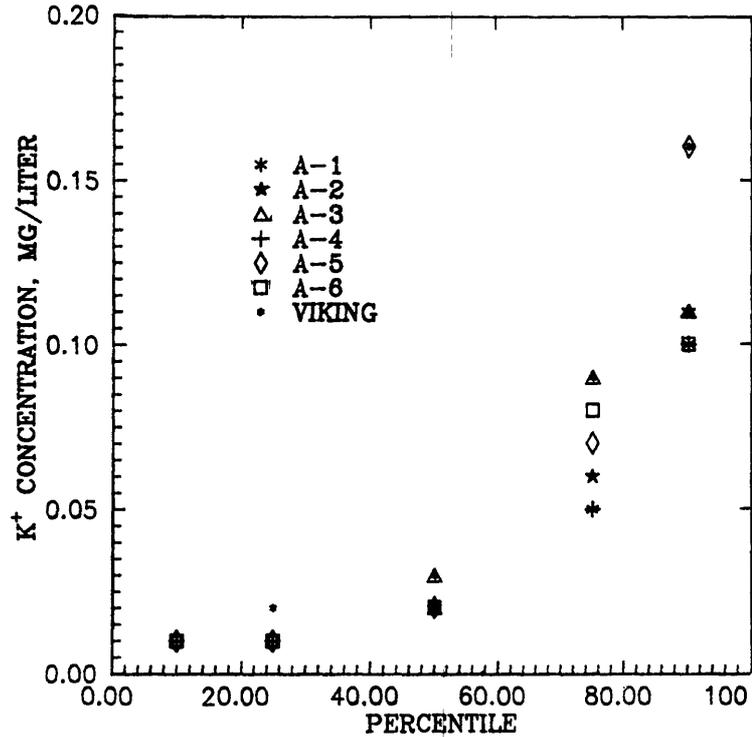


Figure 11.-- Percentile comparison of the concentration of potassium ion. [Samples collected 14 January 1986 - 11 November 1986.]

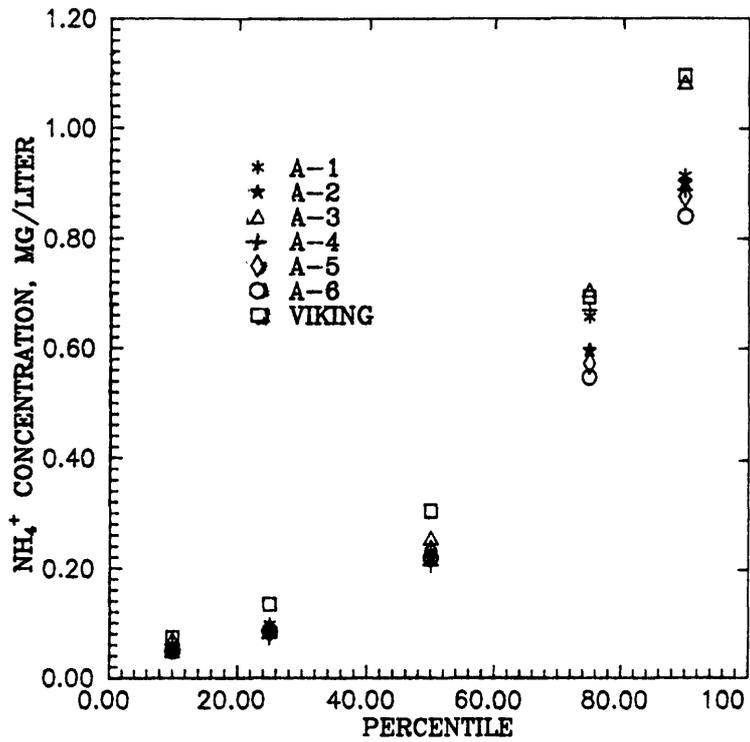


Figure 12.-- Percentile comparison of the concentration of ammonium ion [Samples collected 14 January 1986 - 11 November 1986.]

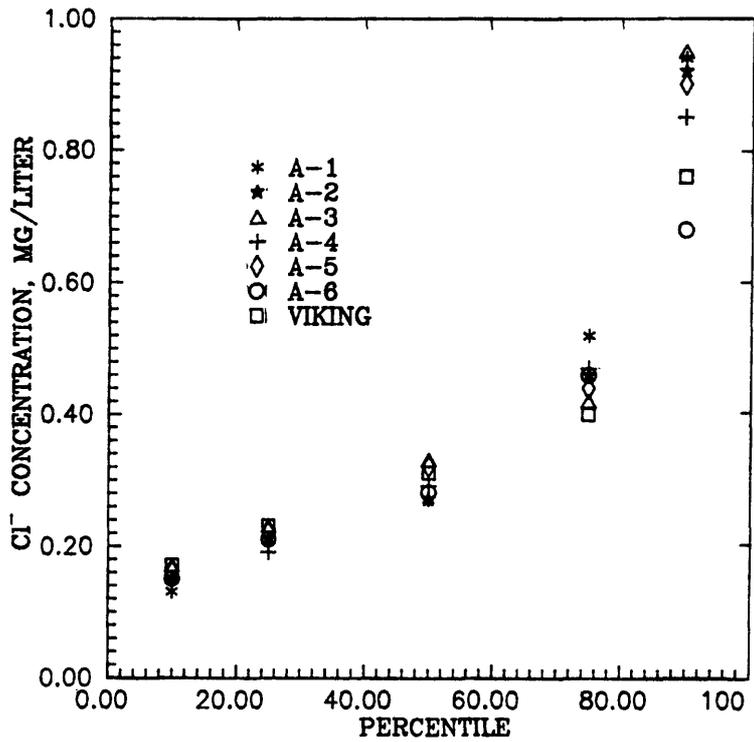


Figure 13.-- Percentile comparison of the concentration of chloride ion [Samples collected 14 January 1986 - 11 November 1986.]

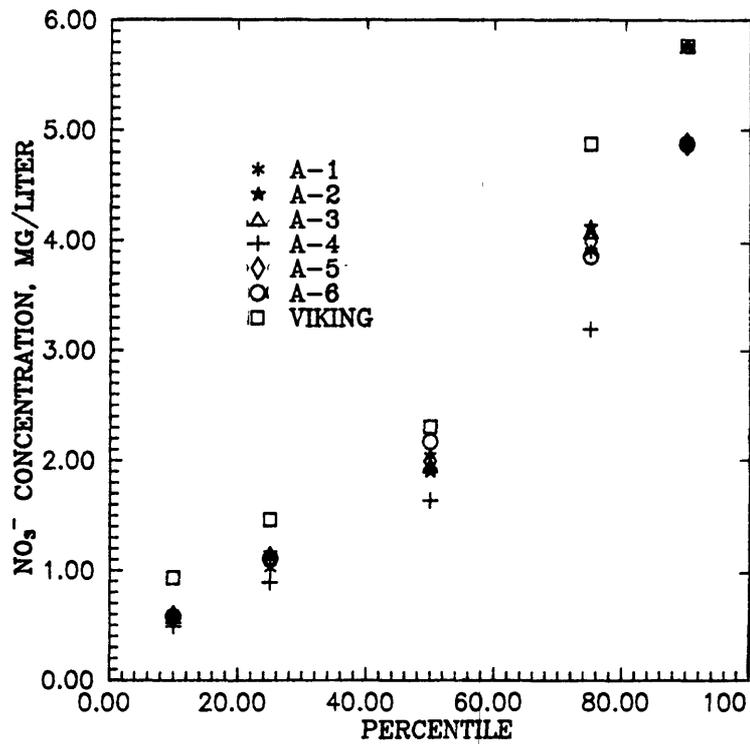


Figure 14.-- Percentile comparison of the concentration of nitrate ion. [Samples collected 14 January 1986 - 11 November 1986.]

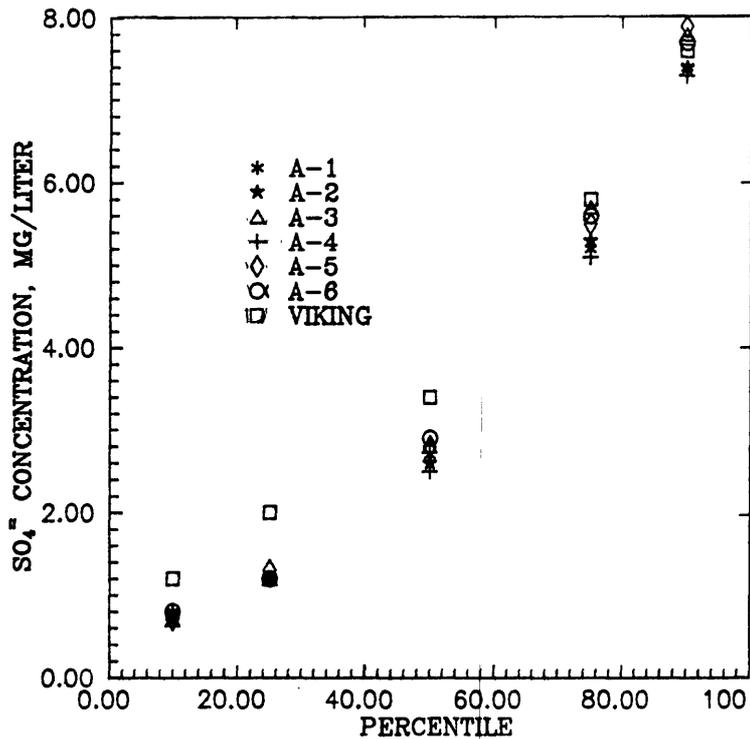


Figure 15.-- Percentile comparison of the concentration of sulfate ion. [Samples collected 14 January 1986 - 11 November 1986.]

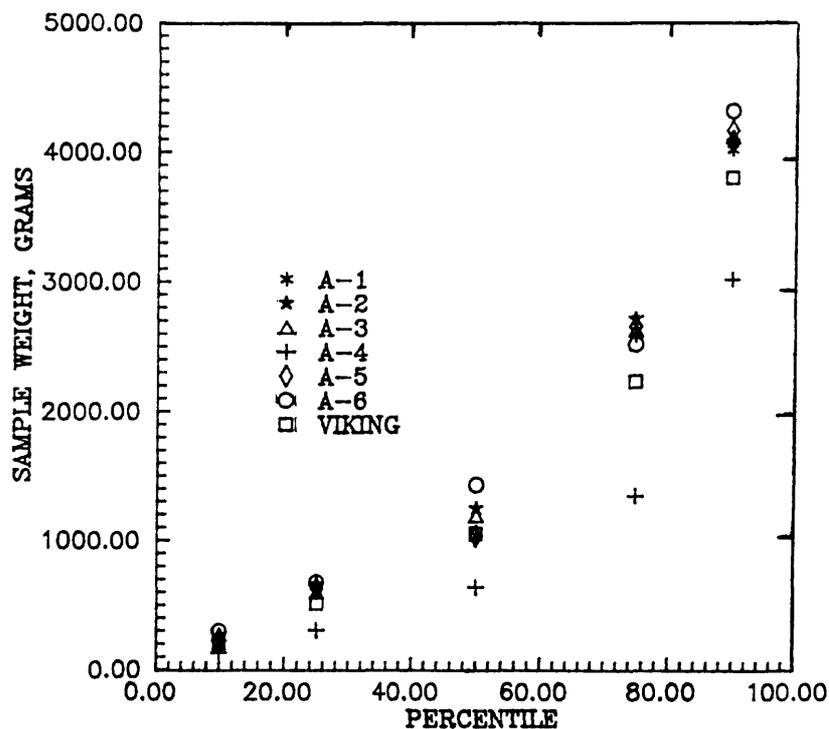


Figure 16.-- Percentile comparison of the concentration of sample weight.
[Samples collected 14 January 1986 - 11 November 1986.]

Table 8.-- Volume weighted average concentrations of selected analytes
[Units are milligram per liter, except H^+ which is equivalent/liter. Values calculated using equation 10. $FH^+ = [H^+]$ determined at U.S. Military Academy; $LH^+ = [H^+]$ determined at U.S. Geological Survey.]

Sampler	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]	[NO ₃ ⁻]	[SO ₄ ⁼]	FH ⁺ *10 ⁵	LH ⁺ *10 ⁵
A-1	0.092	0.037	0.152	0.030	0.262	0.289	1.978	2.97	8.1	7.7
A-2	.093	.037	.148	.030	.260	.308	2.017	2.99	7.7	7.8
A-3	.088	.039	.143	.046	.317	.317	2.091	3.12	6.8	7.8
G-4	.081	.033	.138	.027	.252	.287	1.748	2.75	6.9	6.7
A-5	.107	.044	.128	.037	.264	.295	1.999	3.00	7.1	7.6
A-6	.090	.033	.152	.030	.251	.282	1.969	2.78	7.2	7.0
V-7	.135	.044	.166	.065	.399	.314	2.157	3.19	7.7	7.8
A2DUP	.078	.034	.154	.035	.259	.307	2.024	2.92	7.7	7.7

Where $[A]_i$ is the concentration of the analyte in the i th week,
Volume _{i} is the volume of the sample in the i th week, and

$\overline{[A]}$ is the volume weighted concentration for the sampling period.

A deviation in performance between samplers is inferred if the magnitude of the difference of volume-weighted average concentrations between samplers exceeds the difference of volume-weighted average concentrations between sampler A-2 and the volume-weighted average concentration of the duplicate of sampler A-2. Although this difference will give a qualitative indication of any difference in performance beyond analytical precision, a problem does exist with this procedure. The problem with just using the difference of the volume weighted means between A-2 and A-2 duplicate is that the confidence interval about the two means is not known. In general, paired t-tests for the difference between the concentration of the analyte in A-2 and the concentration of the analyte in the duplicate of A-2 indicated that there was no difference between the two samples. However, the statistical test was for the concentration and not for the volume-weighted average concentration. Summaries of the samplers which had a difference greater than or equal to the difference between the concentration of A-2 and the duplicate of A-2 are given in tables C-15 to C-24 in appendix C.

Deposition Differences

In addition to the calculation of Friedman variables for the differences in concentration, the Friedman variables have been calculated for the deposition load of the various ions. The deposition was calculated as the product of the concentration of the ion times the sample volume (density of the precipitation was assumed to be unity). The units of the deposition would then be mg/week. The area over which the deposition occurred was the area of the cross section of the bucket at the rim (627 cm²).

The number of pairwise differences for the Friedman test applied to deposition is very striking and reflects the interdependence of total deposition on both chemistry and amount of the precipitation. Significant differences exist for all analytes using deposition as the analysis variable.

The hypotheses that are tested are as before:

H₀ : The samplers (treatments) have identical depositions (effects), and

H₁ : At least one of the samplers (treatments) tends to yield larger observed deposition values than at least one other sampler (treatment).

The summary of results of the Friedman test for deposition load of each of the analytes is given in table 9. The results for pairwise comparisons for each of the analytes are given in tables 10-19. Many of these differences are even more striking than when sample weight or concentration data are taken individually. The Friedman test was applied both to deposition calculated as the product of concentration of analyte times the volume collected in the sampler and calculated as the product of the concentration of analyte times the equivalent volume collected in the NADP rain gage. The Friedman results in tables 10-19 are for the former

method and the tables in appendix G are shown for the latter method. The numbers change slightly but the overall pattern of differences is the same.

The reasons for the differences in performance will be examined in light of the objectives of the study:

1. To study the performance of non-standard NADP/NTN atmospheric deposition samplers. Performance of the Viking and Geotech 650 sampler were compared to the Aerochem Metrics 301 atmospheric deposition sampler (the sampler standard for the NADP/NTN).
2. To study the small distance spatial variability of sample weight and chemistry of wet atmospheric deposition. Two samplers were located approximately 4 km apart. It was hypothesized that that small-scale differences in amount of precipitation and precipitation chemistry might occur between these sites.
3. To study the validity of the criteria used in siting precipitation samplers. Several of the criteria were specifically compromised so as to be able to ascertain if the criteria were valid in the establishment of monitoring sites.

Performance of Non-standard (NADP/NTN) Wet Atmospheric Deposition Samplers

Length of Time of Opening

In addition to the chemical and sample weight data, additional data on sampler performance was also collected. As indicated in the experimental section, the voltage on the event strip of each sampler was monitored. The resulting tables of opening and closing times collected and recorded by the microdatalogger were evaluated by calculating the length of time that each sampler was open throughout the duration of the study. Unfortunately, each sampler did not open or close at the same time as each of the other samplers, nor did each stay open the same amount of time. The length of time was calculated using the program reported by Graham and others (1987).

The computer program determines if the lid position of the sampler changes from one recorded value to the next. If the lid position changes, a decision is made whether the lid position changed to the opposite position from open or closed. If the change was from wet bucket closed to open, a variable to record the time at which the sampler opened was initialized. If the change was from open to closed, the beginning time is subtracted from the ending time and the difference recorded. The frequency distribution diagrams¹ and percent cumulative frequency plots²

¹. The frequency distribution diagrams represent the number of times that a collector was open for a given length of time.

². The percent cumulative frequency plots represent the cumulative sum of number of times a collector was open for less than a given time normalized to a percent of the total number of openings.

Table 9.-- Summary results of statistical analysis using the Friedman test for deposition data [Results are for the statistical analysis of all samplers except the duplicate analysis of A-2.]

Analyte	A ₂ (1)	B ₂ (1)	T ₂ (1)	F _{table} (2) α=0.01	Significant at α=0.01	F _{table} (2) α=0.05	Significant at α=0.05
Calcium	5179.5	4479.6	17.26	3.174	Y	2.274	Y
Chloride	5039.5	4420.4	21.95	3.192	Y	2.282	Y
Field H ⁺	5319.5	4672.0	23.77	3.156	Y	2.266	Y
Potassium	5320.0	4585.3	16.58	3.156	Y	2.266	Y
Lab H ⁺	5319.5	4674.3	23.99	3.156	Y	2.266	Y
Magnesium	5291.5	4606.4	18.92	3.156	Y	2.266	Y
Sodium	5319.5	4584.5	16.53	3.156	Y	2.266	Y
Ammonium	5320.0	4585.3	16.58	3.156	Y	2.266	Y
Nitrate	5320.0	4584.1	16.50	3.156	Y	2.266	Y
Sulfate	5179.0	4587.6	27.00	3.174	Y	2.274	Y

1. A₂, B₂ and T₂ are the numbers calculated for the Friedman test.
2. F_{table} is the F-value to which T₂ is compared.
3. Equal performance is rejected when hypothesis H₀ is rejected. Alternatively, at least one sampler pair has a significant pairwise difference.

Table 10.-- Summary of sum of rank differences as indicated by Friedman test --- calcium deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows = 37; number of columns = 7. T2 = 17.27; F-value ($\alpha= 0.01$) 3.174; F-value ($\alpha= 0.05$) 2.274. Significant difference value = 31.59. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	44.00*	69.50*	38.50*	68.50*	65.50*	88.50*
A-2		25.50	82.50*	24.50	21.50	44.50*
A-3			108.00*	1.00	4.00	19.00
G-4				107.00*	104.00*	127.00*
A-5					3.00	20.00
A-6						23.00

Table 11.-- Summary of sum of rank differences as indicated by Friedman test --- chloride deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 36; number of columns = 7. T2= 21.96; F-value ($\alpha= 0.01$) 3.192; F-value ($\alpha= 0.05$) 2.282. Significant difference value= 29.72. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	43.00*	75.50*	49.50*	79.50*	63.50*	71.50*
A-2		32.50*	92.50*	36.50*	20.50	28.50
A-3			125.00*	4.00	12.00	4.00
G-4				129.00*	113.00*	121.00*
A-5					16.00	8.00
A-6						8.00

Table 12.-- Summary of sum of rank differences as indicated by Friedman test --- field H⁺ deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 23.78; F-value (α = 0.01) 3.156; F-value (α = 0.05) 2.282. Significant difference value= 30.37. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	53.00*	64.50*	56.50*	76.50*	92.50*	46.50*
A-2		11.50	109.50*	23.50	39.50*	6.50
A-3			121.00*	12.00	28.00	18.00
G-4				133.00*	149.00*	103.00*
A-5					16.00	30.00
A-6						46.00*

Table 13.-- Summary of sum of rank differences as indicated by Friedman test --- potassium deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 16.59; F-value (α = 0.01) 3.156; F-value (α = 0.05) 2.266. Significant difference value= 32.35. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	25.00	84.00*	33.00*	63.00*	70.00*	85.00*
A-2		59.00*	58.00*	38.00*	45.00*	60.00*
A-3			117.00*	21.00	14.00	1.00
G-4				96.00*	103.00*	118.00*
A-5					7.00	22.00
A-6						15.00

Table 14.-- Summary of sum of rank differences as indicated by Friedman test --- lab H^+ deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 24.00; F-value ($\alpha= 0.01$) 3.156; F-value ($\alpha= 0.05$) 2.266. Significant difference value= 30.32. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	51.00*	84.50*	53.50*	82.50*	78.50*	54.50*
A-2		33.50*	104.50*	31.50*	27.50	3.50
A-3			138.00*	2.00	6.00	30.00
G-4				136.00*	132.00*	108.00*
A-5					4.00	28.00
A-6						24.00

Table 15.-- Summary of sum of rank differences as indicated by Friedman test --- magnesium deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 18.93; F-value ($\alpha= 0.01$) 3.156; F-value ($\alpha= 0.05$) 2.266. Significant difference value= 31.59. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	32.00*	78.50*	53.50*	68.50*	48.50*	67.50*
A-2		46.50*	85.50*	36.50*	16.50	35.50*
A-3			132.00*	10.00	30.00	11.00
G-4				122.00*	102.00*	121.00*
A-5					20.00	1.00
A-6						19.00

Table 16.-- Summary of sum of rank differences as indicated by Friedman test --- sodium deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 16.54 F-value ($\alpha= 0.01$) 3.156; F-value ($\alpha= 0.05$) 2.372. Significant difference value= 32.36. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	28.00	49.50*	70.50*	46.50*	30.50	66.50*
A-2		21.50	98.50*	18.50	2.50	38.50*
A-3			120.00*	3.00	19.00	17.00
G-4				117.00*	101.00*	137.00*
A-5					16.00	20.00
A-6						36.00*

Table 17.-- Summary of sum of rank differences as indicated by Friedman test --- ammonium deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 16.58; F-value ($\alpha= 0.01$) 3.156; F-value ($\alpha= 0.05$) 2.266. Significant difference value= 32.35 * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	29.00	59.00*	63.00*	49.00*	45.00*	70.00*
A-2		30.00	92.00*	20.00	16.00	41.00*
A-3			122.00*	10.00	14.00	11.00
G-4				112.00*	108.00*	133.00*
A-5					4.00	21.00
A-6						25.00

Table 18.-- Summary of sum of rank differences as indicated by Friedman test --- nitrate deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 16.50 F-value ($\alpha= 0.01$) 3.156; F-value ($\alpha= 0.05$) 2.266. Significant difference value= 32.38. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	28.00	61.00*	63.00*	49.00*	47.00*	67.00*
A-2		33.00*	91.00*	21.00	19.00	39.00*
A-3			124.00*	12.00	14.00	6.00
G-4				112.00*	110.00*	130.00*
A-5					2.00	18.00
A-6						20.00

Table 19.-- Summary of sum of rank differences as indicated by Friedman test --- sulfate deposition [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 37; number of columns = 7. T2= 27.01; F-value ($\alpha= 0.01$) 3.192; F-value ($\alpha= 0.05$) 2.266. Significant difference value= 29.04. * indicates significant difference.]

Samplers	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	38.00*	91.00*	51.50*	72.00*	57.50*	90.50*
A-2		53.00*	89.50*	34.00*	19.50	52.50*
A-3			142.50*	19.00	33.50*	0.50
G-4				123.50*	109.00*	142.00*
A-5					14.50	18.50
A-6						33.00*

(in appendices H and I) reveal some striking differences in the performance of the samplers. The data is summarized in table 20. The percentiles of the distributions reveal very striking differences between the samplers and the amount of time that a sampler was open. The Viking (V-7) and the Geotech 650 (G-4) are obviously skewed towards lower lengths of opening than are the other samplers.

Table 20.-- Summary of sampler performance based on length of time (minutes) that the sampler is open [Minimum for all samplers is 1 minute.]

Samplers	Number of Openings	Percentile					Maximum
		10	25	50	75	90	
Minutes							
A-1	535	2	6	14	37	103	573
A-2	566	4	7	13	35	108	547
A-3	722	2	4	10	24	111	800
G-4	1751	1	1	3	7	13	366
A-5	573	2	5	11	33	104	561
V-7	1288	1	1	1	5	49	725

Four of the samplers (A-1, A-2, A-3, and A-5), exhibit similar cumulative distribution functions. All of these samplers had nearly the same sensor sensitivity. The two that are markedly different are V-7 and G-4. Upon examination of the cumulative frequency distribution for length of opening, one sees that the number of openings is highly skewed to short times for both of these samplers. It is also noted from table 2, that the sensitivity of each of these sensors is considerably higher than for the Aerochem samplers. This is in accord with work previously reported (Graham and others 1987). In that study the data seemed to indicate that the cumulative frequency was slightly affected by the sensitivity, but that the differences were slight for sensitivity settings of 55 and 70 K Ω . The study reported in this report has a much more marked range of sensor sensitivities. The length of time that a sampler is open seems to be correlated with the sensitivity of the sensor. The cumulative frequency plots show that as the resistance of the sensor increases the length of time the sampler is open decreases. Figure 17 shows the relation between the ninetieth percentile of time that the sampler is open and the resistance of the sampler. As with previously reported work (Graham and others, 1987; Graham and others, 1988), the reason may lie in the design of the sensor and the sensor circuit for the Viking sampler. The Viking sampler cycled a great deal more than the Aerochem samplers as seen by the much higher number of openings as seen in table 20. The temperature of the Viking sensor was also much greater than the Aerochem samplers (table 2), which leads to faster evaporation of the precipitation from the sensor and more frequent cycling. The Aerochem samplers, when activated, would execute an entire cycle. The lid position is initially over the wet bucket, then the lid moves to cover the dry bucket and finally returns to cover the wet bucket. Generally, it pauses for some time over the dry bucket before returning to the closed position. However, the Viking did not operate in a similar manner. The cycle would begin with the lid over the wet bucket, but if the precipitation on the sensor dried before the lid moved completely

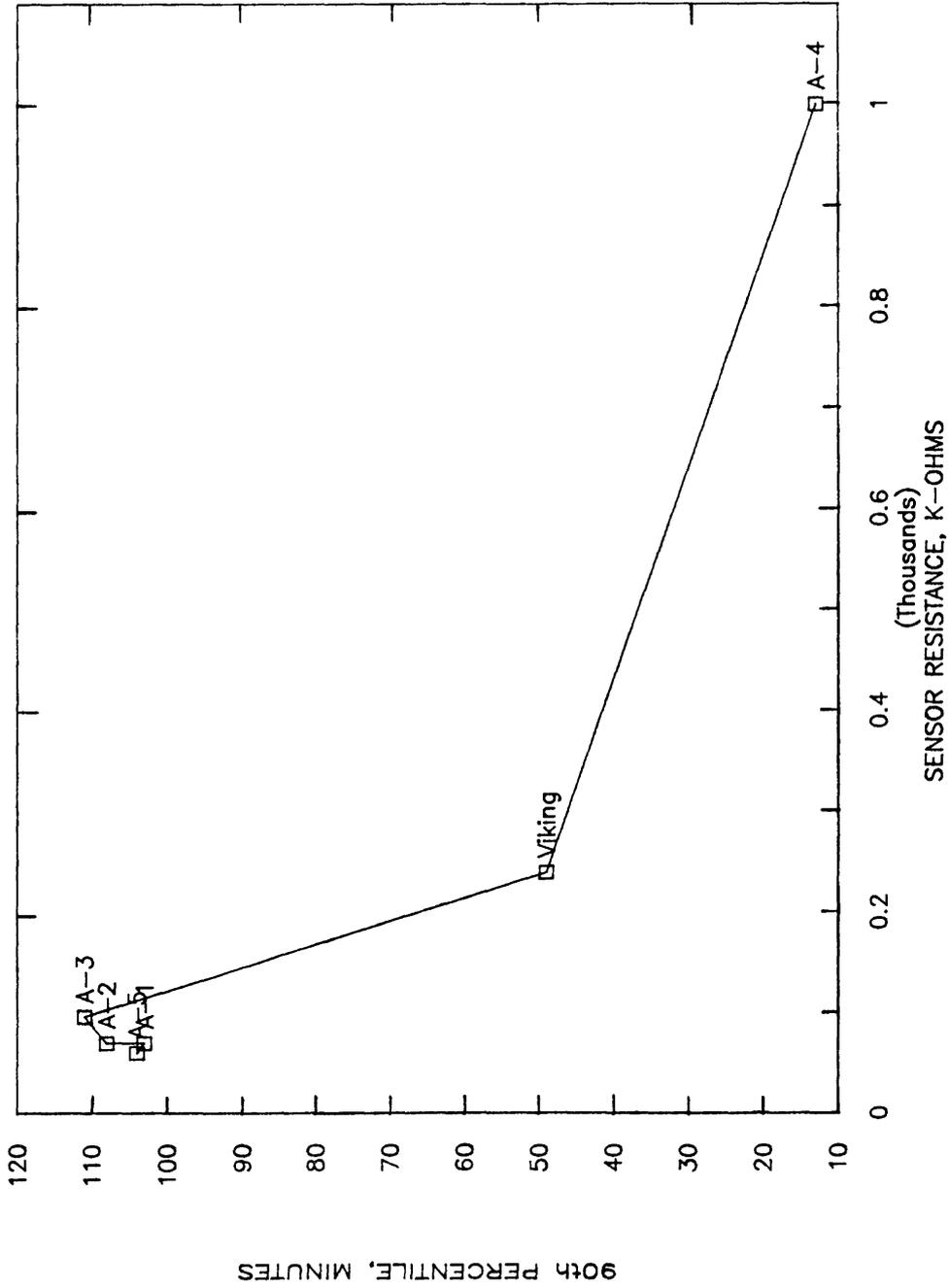


Figure 17.-- Relation of the ninetyeth percentile of length of opening to sensor sensitivities (resistances).

over the dry bucket, the cycle would be interrupted and the lid would return immediately to cover the wet bucket. Each time that this occurred, the counter that recorded the number of openings on the Viking would increment by one. The microdatalogger would generally also record this as an opening of the sampler.

This cycling of the sampler is evidenced by the large number of openings (at least 50 percent of the total) which were only one minute. 75 percent of the openings were 5 minutes or less in duration. The most striking of the samplers, however, was G-4 which evidenced 90 percent or more of the openings being only 13 minutes or less. Table 2 indicates that the resistances of the sensors for the Geotech 650 and the Viking samplers are much higher than for the Aerochem Metrics 301 samplers. The sensitivity of the sensor is thus very important in governing the length of time that a sampler is exposed to precipitation. Part way through the study the motor box (control unit) on A-3 had to be changed with a resultant change in the resistance of the sensor from 70K Ω to 96K Ω . The cumulative frequency distribution of the samplers (fig. 18) qualitatively indicates that the higher the resistance, the more the distribution is skewed towards lower lengths of openings. It is seen that the cumulative frequency distribution of A-3 is skewed slightly more towards the lower lengths of opening than are the other Aerochem Metrics 301 samplers. The same effect was noted from the data presented by Graham and others (1988).

The graphs of cumulative frequency and the relative frequency diagrams from which they were derived (appendices H and I) indicate that there are substantial differences in the sampler performance between the Aerochem Metrics 301, the Viking and the Geotech 650 samplers.

Cycle Time

The cycle time of each sampler has been measured, and although, the average cycle time of collection differs for each type of sampler (58 seconds for Viking sampler, 42 seconds for the GeoTech 650, and 22 seconds for Aerochem Metrics samplers), the fact that each type of sampler cycles a different number of times during an event is felt to be the more predominant factor in defining sampler performance, although the cycle time may affect the catch efficiency particularly during intense periods in a storm. This would be especially noted for those samplers which cycle a large number of times in a precipitation event.

Spatial Variability

The effect of separation of samplers by some distance is also examined in this study. Sampler A-3 is taken as the control and sampler A-6, located approximately 4 km away, is the comparison. Table 4 indicates that the two samplers compare quite favorably for the amount of precipitation caught in the sampler in terms of sample weight. The concentrations of analytes are significantly different for all analytes except sodium and pH determined at U.S. Military Academy (tables F-1 to F-12; appendix F). However, deposition for all analytes is not significantly different over the distance except for sulfate (tables 10-19), even though the terrain is quite varied over

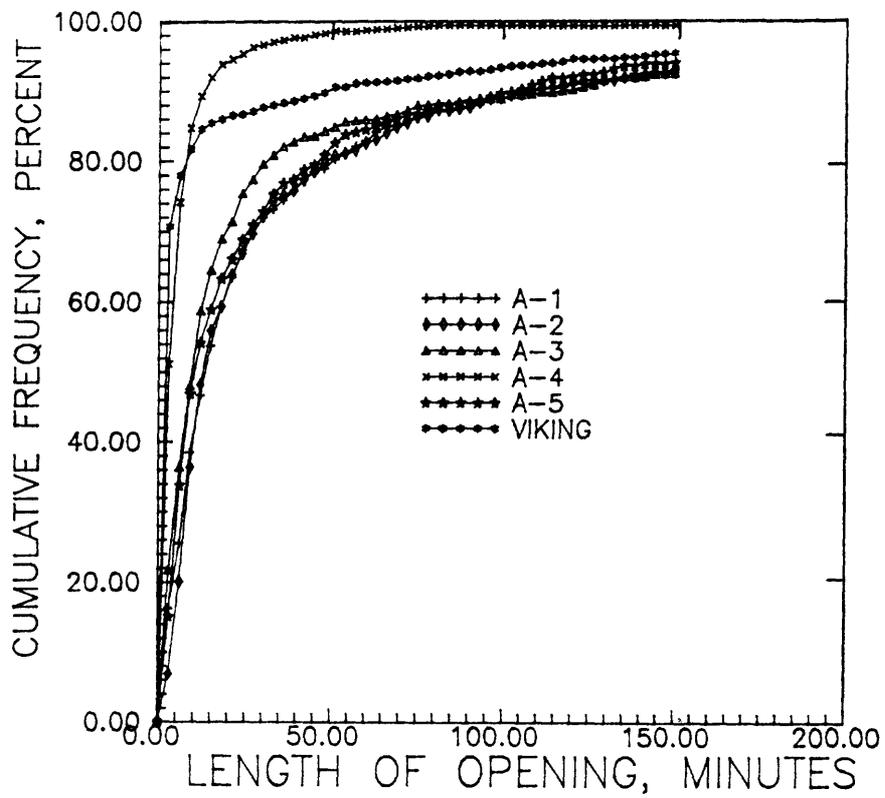


Figure 18.-- Cumulative frequency distributions of the length of time that samplers were open.

that distance with a slight difference of elevation (204 m at A-3 and 296 m at A-6). The reliability of selecting a site that may be representative for a given radius may be enhanced by these results. Further investigation is necessary to determine how large that radius may be.

Compliance with Siting Criteria

The implications of the statistically significant differences that are evident from the Friedman test are more important when examined in light of compliance with the accepted siting criteria of the NADP/NTN. In this study three siting criteria of the National Trends Network/National Atmospheric Deposition Program were purposely compromised:

1. "Objects with sufficient mass to deflect the wind (with the exception of Alter windshields) over 1 meter high will not be located within 5 meters of the sampler." (Number 5 in appendix A)
2. "No object or structure shall project onto the sampler or rain gauge with an angle greater than 45 degrees from the horizontal (30 degrees is considered optimal, but 45 degrees is the highest angle acceptable). Therefore the distance from the sampler to the object must be at least equal to the height of the object (preferably twice the height of the object). Pay particular attention to the anemometer towers and overhead wires." (Number 9 in appendix A)
3. "Frequent moving sources of pollution, such as air, ground or water traffic or the medium on which they traverse (e.g. runway, taxiway, road, tracks, or navigable river) within 100 meters of the sampler. The local road net around the site is of particular concern." (Number 12 in appendix A)

These three criteria were compromised by placing sampler A-5 about 30 m from a state highway; Sampler A-1 was placed within 1.5 m of a large shelter (2.44 m x 2.44 m x 3.05 m) (compromises criteria 1 and 2 above) and sampler A-2 had an Alter windshield placed about the sampler in the same manner as would be placed about a rain gage. In this study, inclusion of an Alter windshield around sampler A-2 violates the spirit of the criterion. The criterion as stated previously did not anticipate the erection of an Alter windshield around other than a rain gage. Sampler A-1 was also placed such that a telephone pole was in the 45° cone (violates criteria 2). Sampler A-3 is the control sampler for all comparisons and is placed in such a manner as to agree with all the siting criteria. Sampler G-4 was a Geotech 650 sampler. Sampler A-6 (an Aerochem Metrics 301 sampler) was located approximately 4 km from the cluster and approximately 67 m from a state highway.

The results of the Friedman test for sample weight and collection efficiency show dramatically different collection characteristics for each of the samplers. The Friedman test indicates that the only two samplers which are not significantly different from the control (A-3) are A-5 and

A-6. This is especially interesting since these three samplers are the only standard samplers that do not compromise siting criteria 1 or 2 above. The fact that the catch efficiency/sample volume is significantly different for compromise of criteria 1 and 2 indicates that the criteria need to be strictly adhered to in siting of samplers for similar studies of atmospheric deposition. Of less importance in siting criteria for catch efficiency is the criteria of closeness to the road. Although the criteria state that Alter windshields may be located within 5 m of the sampler, this should be avoided unless the rain gage is similarly shielded. Table 6 showed that the only rain gage that had a different catch was the one which had an Alter windshield.

To examine the effects of siting close to a road/highway, the dependence of concentration on distance from the highway needs to be examined. Figures 19-23 give plots of the volume weighted average concentrations of each of three analytes (chloride, nitrate and sulfate) for each sampler and for each season of the year. Table 21 gives the distance from the road to the sampler. As can be seen during the winter months (Jan-Mar) of 1986, a general upward trend is noted for the sequence A-5 \geq A-1 \geq A-3 for nitrate and sulfate. The same trend may or may not be evident for the chloride. It is difficult to separate the effect of the distance from the road¹ from the type of sampler. Since G-4 and V-7 both are nonstandard (in the sense of NADP/NTN standard) atmospheric deposition samplers, the higher volume weighted concentrations noted may be because of the difference in performance of the samplers rather than the distance from the road. The higher concentrations could partially be explained on the basis of the frequent cycling and more sensitive nature of these samplers. The effect of increasing concentration is still evident, however, for the other Aerochem Metrics 301 samplers during the winter 1986 sampling period for sulfate and nitrate. Trends for the other seasons are not as evident especially if G-4 and V-7 are excluded from the interpretation. It is rather disturbing that the concentration of nitrate and sulfate increase with distance from the road since one would expect that the concentration would decrease with increasing distance from the road. Examination of windroses for the period of time does not lend a possible explanation. No point sources are located near the samplers that would account for such a disparity.

Table 21.-- Distance from the road for each sampler [Sampler A-6 is not on the same perpendicular as the other samplers.]

Distance from road (meters)	Sampler
32.3	A-5
67.1	A-6
75.0	A-1
96.0	A-2
114.3	A-3
137.5	V-7
144.2	G-4

¹ The road is a state maintained two-lane highway of moderate traffic density (about 100 cars/hour).

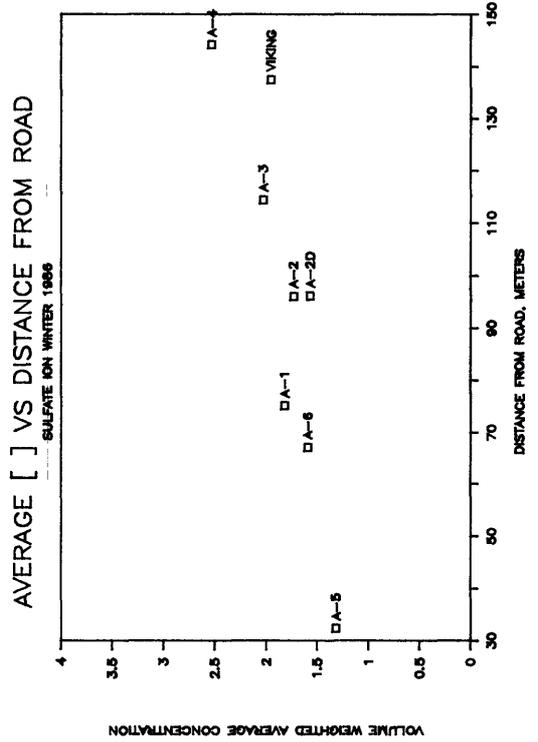
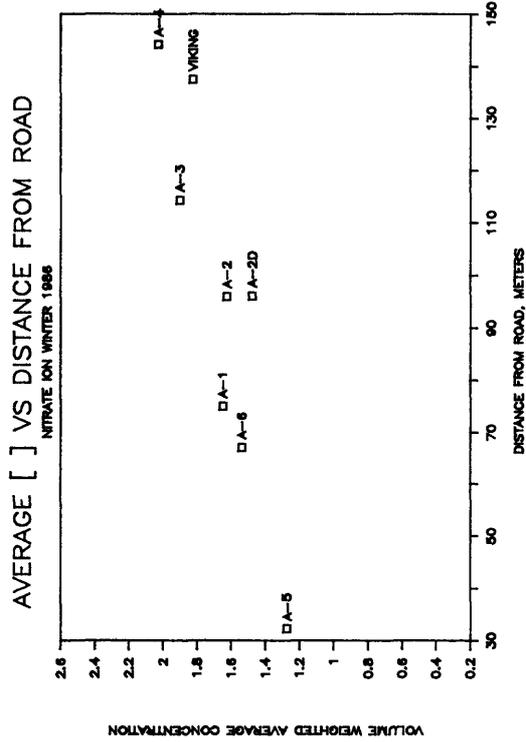
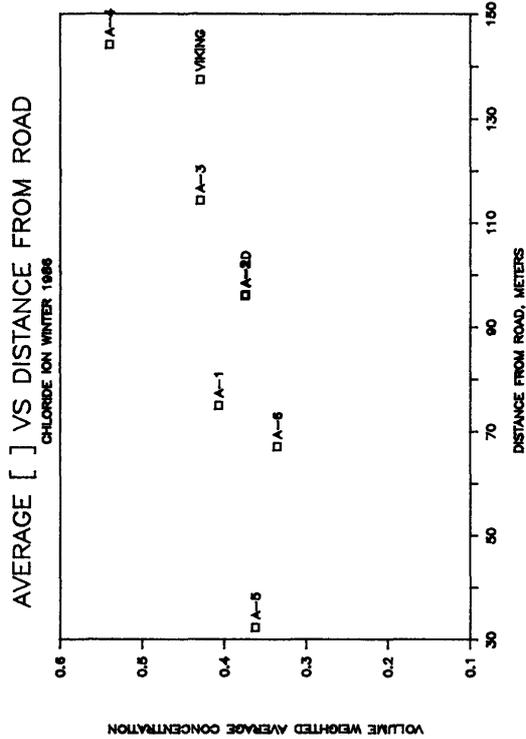


Figure 19.— Winter 1986 Volume Weighted Average Concentrations (milligrams/liter) of chloride, nitrate and sulfate ions as a function of distance from the road.

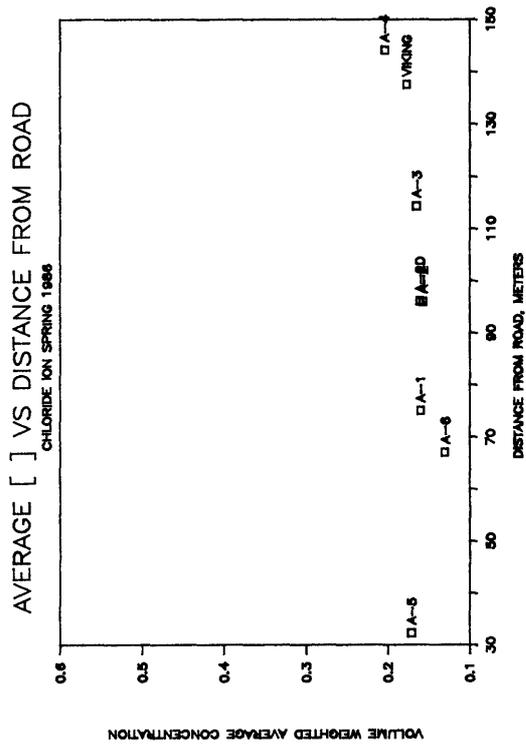
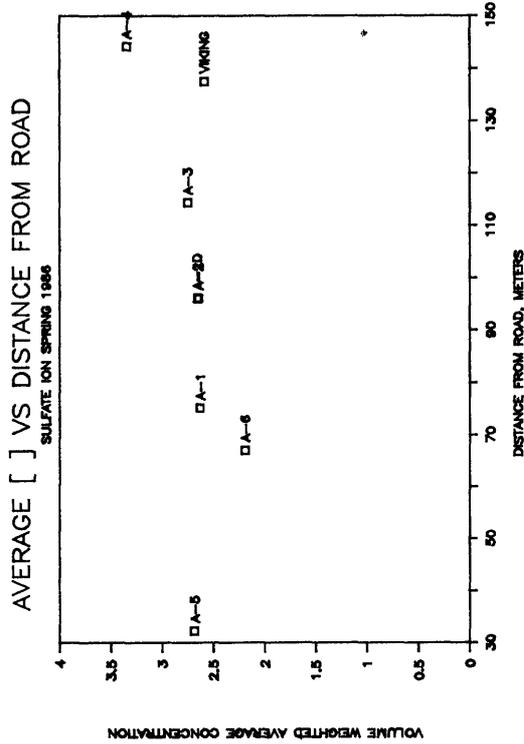
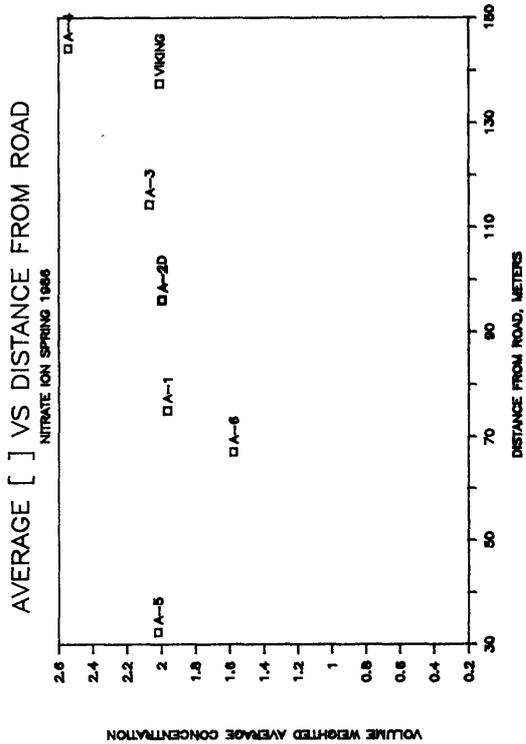
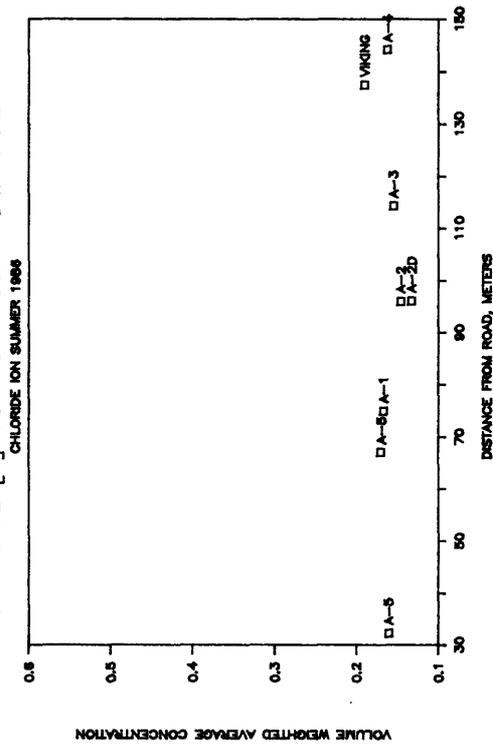
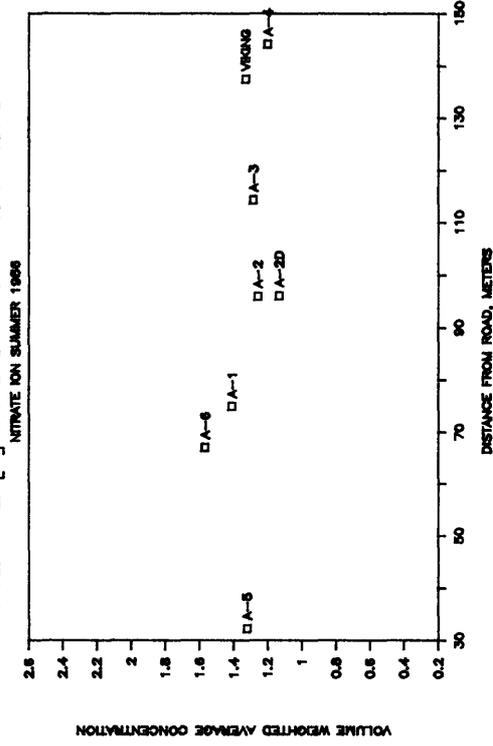


Figure 20.--- Spring 1986 Volume Weighted Average Concentrations (milligram/liter) of chloride, nitrate and sulfate ions as a function of distance from the highway.

AVERAGE [] VS DISTANCE FROM ROAD



AVERAGE [] VS DISTANCE FROM ROAD



AVERAGE [] VS DISTANCE FROM ROAD

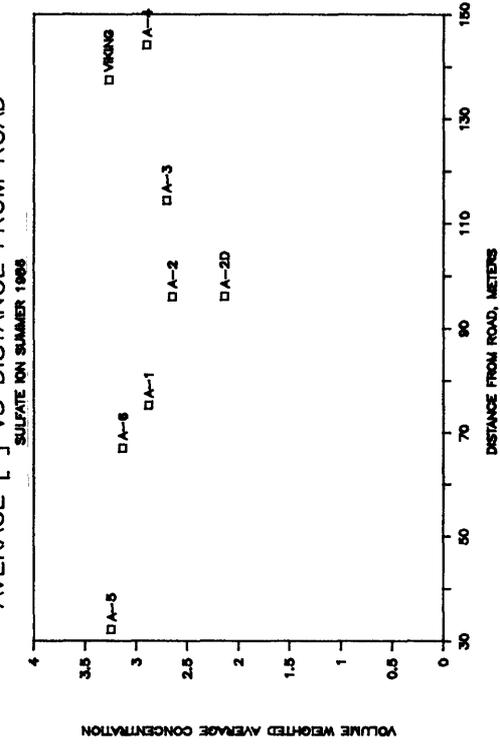


Figure 21.-- Summer 1986 Volume Weighted Average Concentrations (milligrams/liter) of chloride, nitrate and sulfate ions as a function of distance from the highway.

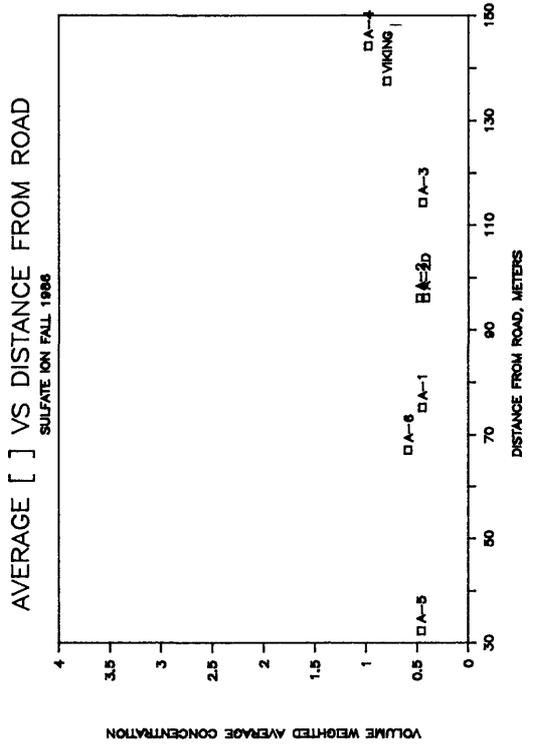
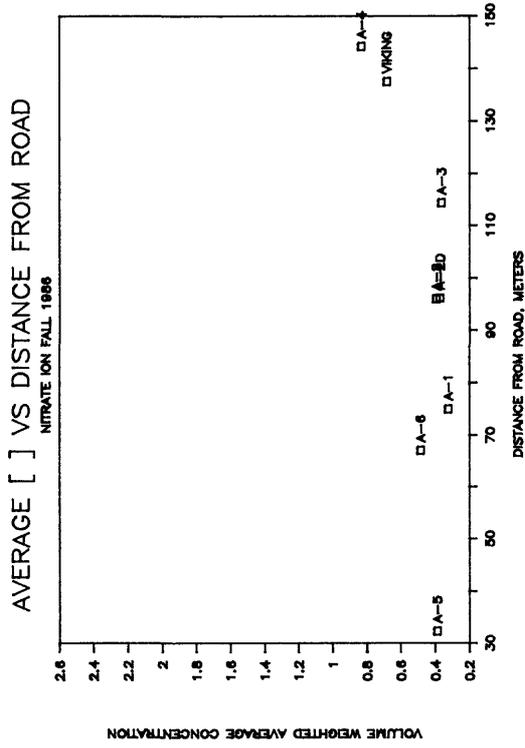
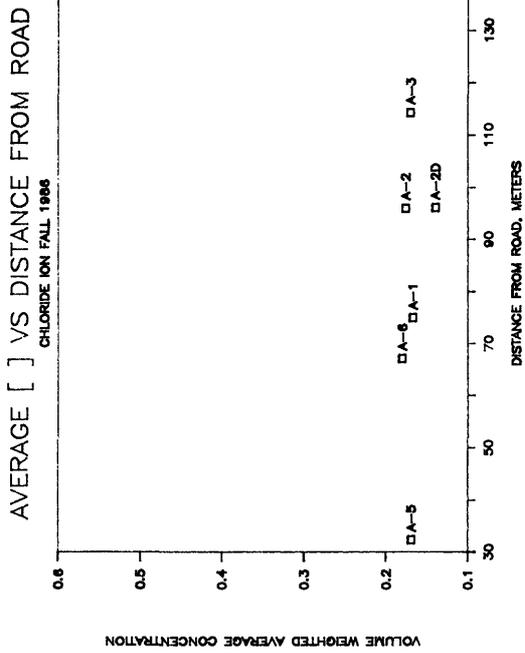


Figure 22. -- Fall 1986 Volume Weighted Average Concentrations (milligrams/liter) of chloride, nitrate and sulfate ions as a function of distance from the highway.

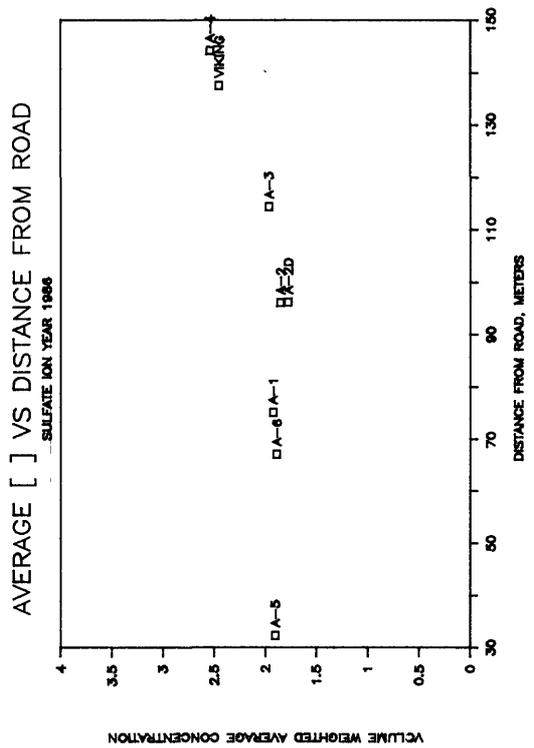
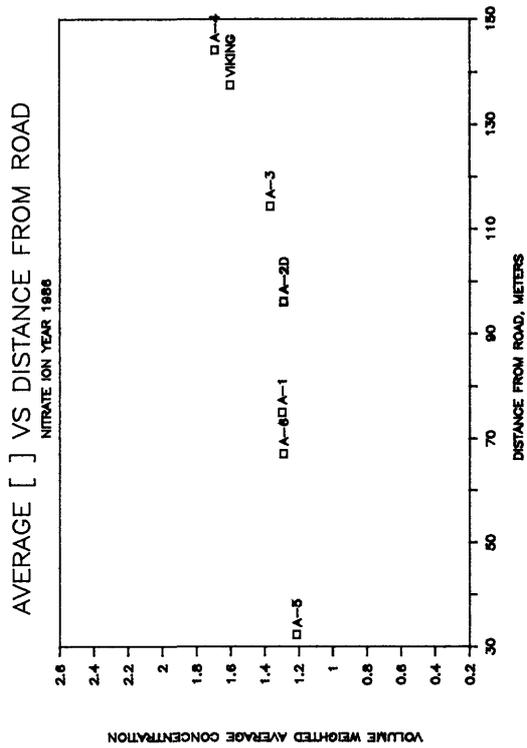
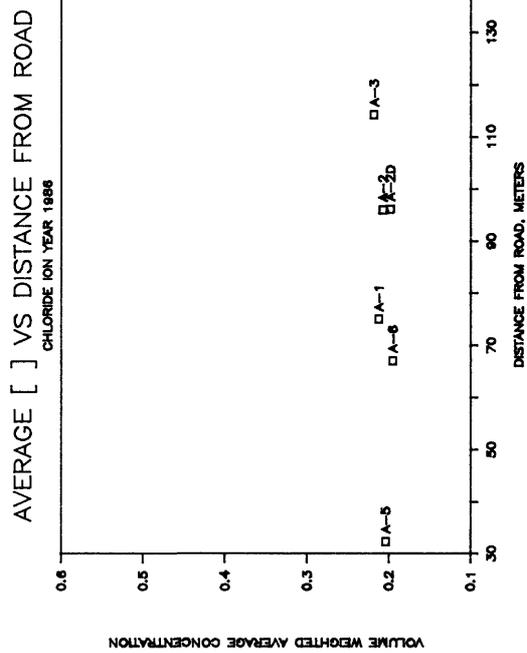


Figure 23.-- 1986 Volume Weighted Average Concentrations (milligrams/liter) of chloride, nitrate and sulfate ions as a function of distance from the highway.

SUMMARY AND CONCLUSIONS

General

This report discussed the aspects of data analysis by parametric and nonparametric statistical tests; the small-scale spatial variability of precipitation quantity and chemistry; the causes for differences in performance of Aerochem Metrics 301, GeoTech 650 and Viking atmospheric deposition samplers, and the effects of not meeting the siting criteria.

A nonparametric approach in the analysis of sampler performance is advantageous because it is not as restrictive in its assumptions as the traditional ANOVA approach. The procedures of the nonparametric Friedman test are simple to apply and pairwise comparisons of samplers are possible. Although the magnitudes of differences are not possible to calculate, it is possible to discern general trends in the performance between samplers. Two indicators of magnitude of differences were developed. One of the indicators is the trend in the percentile distributions of each analyte, and the second was related to magnitude of the precision of the analytical method. Volume weighted average concentrations were calculated for each analyte and each sampler. A disparity in performance between the two samplers was assumed if the difference between the volume weighted average concentrations of two samplers exceeded the difference between the volume weighted average concentrations of duplicate analyses that were performed on samples from Sampler A-2. This procedure assumed that the difference between duplicate analyses could be explained by laboratory precision.

Results indicate that the difference in duplicate determinations of all analytes is not significant at the $\alpha = 0.05$ significance level. This implies that the laboratory precision is quite high. Additionally, this study has shown that there is no significant difference between the pH and specific conductance of the precipitation samples as measured at the U.S. Military Academy and at the U.S. Geological laboratories.

Deposition calculated as the product of concentration times the volume in the sampler and deposition calculated as the product of concentration times the equivalent volume collected in a rain gage are not significantly different.

The major factor controlling differences in deposition appears to be the collection efficiency of the sampler.

Sampler Performance

The Aerochem Metrics 301 samplers have been shown to remain open for significantly longer periods of time than the GeoTech 650 or Viking atmospheric deposition samplers. The common conception that the sampler remains open until the termination of the precipitation event is invalid. All samplers were seen to cycle (sometimes frequently) during a precipitation event, depending upon the design of the sensor. The GeoTech 650 and Viking samplers cycled more frequently during a precipitation event than did the Aerochem Metrics 301 samplers.

Spatial Variability

The two samplers which were used to test spatial variability of wet atmospheric deposition across 4 km indicated no difference in collection efficiency, sample weight, or deposition of analytes (except sulfate). Statistically significant differences ($\alpha = 0.05$) were detected for the concentration of all analytes, except for pH values determined at the U.S. Military Academy and sodium ion.

Violation of Siting Criteria

The effects of distance from a road is not significant for catch efficiency nor for catch volume, but a difference is detected in concentrations and deposition during the winter months (January to March 1986). A smaller effect is noted for spring and fall, but virtually no difference is noted for the summer months for concentrations or depositions of analytes. The observation that the concentration is directly proportional to the distance from the road indicates that the differences are probably not caused by moving sources, such as automobiles.

The compromise of siting criteria leads to a difference in the performance of samplers. Specifically, the violation of siting criteria that call for exclusion of objects with sufficient bulk to disturb local wind fields leads to a difference in catch efficiency and difference of sample weight. This study has the benefit of increased collection efficiency by having an Alter windshield around the sampler.

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APPENDIX A:Criteria used to establish National Atmospheric Deposition
Program/National Trends Network collection sites (Robertson and others,
1982)

Site Evaluation Criteria

GOAL: To locate sites such that they are outside the noticeable influence of any one emission source and represent an average of atmospheric deposition derived from sources from outside the region plus contribution, after dispersion and mixing, from sources within the region.

Instrument Installation:

1. Recommended installation of the sampler is on the standard 3 foot high aluminum base over undisturbed ground. In areas having an accumulation of over 2 feet of snow per year, the sampler may be raised off the ground on a platform. This platform will be no higher than the maximum anticipated snowpack. In general, platforms are discouraged.
2. The sampler should be oriented with the wet side bucket to the west and the sensor pointing north.
3. Naturally vegetated level areas are preferred, but grassed areas and slopes up to ± 15 percent will be tolerated. If possible, such ground cover should surround the sampler for a distance of approximately 20 meters. The slope should be within the prescribed value in the ground cover area. In farm areas a vegetated buffer strip must surround the sampler for at least 20 meters.
4. The base of the sampler will not be enclosed.
5. Objects with sufficient mass to deflect the wind (with the exception of Alter windshields) over 1 meter high will not be located within 5 meters of the sampler.
6. The rain gauge should not be located within 30 meters of the sampler, but no closer than 5 meters. Its orifice should be located within 1 foot of the same level as the orifice of the sampler.
7. Samplers located in areas which normally receive snow will only have a snow roof installed on the moving lid of the sampler when problems with opening and closing are encountered. Such a lid should be left on year round.
8. Annual vegetation will be maintained at less than 2 feet.

Local Surroundings

9. No object or structure shall project onto the sampler or rain gauge with an angle greater than 45 degrees from the horizontal (30 degrees is considered optimal, but 45 degrees is the highest angle acceptable). Therefore the distance from the sampler to the object must be at least equal to the height of the object (preferably twice the height of the object). Pay particular attention to the anemometer towers and overhead wires.

10. No surface storage of agricultural products, fuels, vehicles, or other foreign materials within 100 meters of the sampler will be allowed. Parking lots and maintenance yards with frequent use are a particular problem.

11. Grazing animals will not be closer than 20 meters of the sampler. Feedlots, dairy barns, etc. in which large concentrations of animals will be housed will be no closer than 500 meters to the sampler.

12. Frequent moving sources of pollution, such as air, ground or water traffic or the medium on which they traverse (e.g. runway, taxiway, road, tracks, or navigable river) within 100 meters of the sampler. The local road net around the site is of particular concern.

13. Residential-type buildings should not be within a 30 degree cone.

Long Range Conditions

14. Continuous industrial-type operations such as factories, chemical plants, power plants, etc. will not be within 10 km of the sampler. Additionally, if the emissions sources are located in the general upwind direction (i.e. the mean annual west-to-east flow in most cases) of the sampler, then they should be not closer than 20 km to the sampler.

15. The sampler should not be located within 10 km of moderate-sized suburban or urban areas. A general definition of this classification is one having 10,000 or more people. This distance is increased to 20 km if the urban area is in the general upwind direction of the sampler. For the larger cities (i.e. populations greater than 75,000) the sampler should no closer than 20 km if it is in the upwind direction, and 40 km it is in the downwind direction.

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**APPENDIX B: Tables of Chemical Data for Precipitation Collected in Wet only
Atmospheric Deposition Samplers**

Table B-1.-- Chemical data for Sampler A-1

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent; ---- indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	853	860121	905	717.9	0.010	0.020	0.260	0.010	0.061	1.200
860121	905	860128	935	5575.1	.010	.030	.240	.010	.036	.440
860128	935	860204	900	752.8	.000	.000	.350	.050	.401	.540
860204	900	860211	930	1035.3	.100	.050	.170	.010	.061	.240
860211	930	860218	905	1114.8	.100	.040	.180	.010	.231	.360
860218	905	860225	845	2036.3	.080	.030	.150	.010	.134	.160
860225	845	860304	715							
860304	715	860311	827	187.4	.310	.100	.600	.100	.923	.930
860311	827	860318	818	2854.1	.030	.020	.160	.020	.121	.270
860318	818	860325	835	243.7	.700	.190	1.100	.100	.862	1.300
860325	835	860401	920	138.4	.540	.170	.230	.060	.716	.520
860401	920	860408	845	915.0	.290	.110	.400	.040	.534	1.000
860408	845	860415	850							
860415	850	860422	843	4025.4	.020	.040	.400	.030	.389	.320
860422	843	860429	857	1795.3	.100	.060	.120	.040	.522	.270
860429	857	860506	850	681.2	.380	.070	.080	.070	.838	.360
860506	850	860513	843	492.9	.360	.060	.100	.090	.838	.390
860513	843	860520	850							
860520	850	860527	855	2077.5	.070	.060	.390	.020	.170	----
860527	850	860603	825	392.0	.910	.180	.010	.080	1.166	----
860603	850	860610	855	5763.9	.240	.050	.120	.020	.267	.210
860610	916	860617	920	2896.7	.140	.020	.040	.010	.182	.130
860617	920	860624	943	255.6	.280	.030	.010	.030	.583	.260
860624	943	860701	930	1002.1	.220	.050	.070	.020	.729	.300
860701	930	860708	932	2658.3	.010	.020	.120	.020	.097	.170
860708	932	860715	925	3320.8	.020	.030	.040	.040	.194	.240
860715	925	860722	911							
860722	911	860729	905	3631.7	.020	.030	.060	.010	.219	.190
860729	905	860805	913	3855.1	.070	.030	.060	.050	.376	.250
860805	913	860812	851	178.4	.180	.050	.210	.040	.656	.000
860812	851	860819	931	673.7	.010	.040	.010	.140	.109	.240
860819	931	860826	919	1518.5	.010	.020	.010	.160	.049	.130
860826	919	860902	937	205.4	.100	.060	.010	.240	.316	.180
860902	937	860909	918	755.6	.050	.030	.100	.120	.704	.400
860909	918	860916	921	253.4	.180	.040	.090	.050	.911	.260
860916	920	860923	940	533.6	.170	.050	.190	.010	1.190	.600
860923	940	860930	927	596.8	.170	.040	.080	.010	.364	.360
860930	927	861007	925	1424.5	.100	.030	.150	.010	.364	.270
861007	925	861014	925	722.6	.070	.030	.070	.010	.085	.120
861014	925	861021	918							
861021	918	861028	705	1037.6	.050	.030	.080	.010	.170	.250
861028	705	861104	604							
861104	604	861111	830	2475.1	.040	.030	.090	.010	.073	.530
861111	830	861118	910	1261.2	----	----	----	----	----	----
861118	910	861125	913	5197.4	.040	.030	.120	.010	.097	.210
861125	913	861202	902	1635.9	.000	.000	.050	----	.061	.140
861202	921	861209	1023	3303.7	.020	.040	.350	.010	.049	.580
861209	910	861216	909	799.6	.050	.020	.030	----	.073	.400
861216	909	861223	927	2590.4	.020	.050	.430	----	.073	.940
861223	927	861230	925	2304.6	.070	.050	.230	.010	.146	.400

Table B-1.-- Chemical data for Sampler A-1 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	853	860121	905	1.063	1.200	4.10	4.20	31.0	31.0	74.35
860121	905	860128	935	.399	.800	4.60	4.60	13.0	12.0	94.27
860128	935	860204	900	4.871	3.000	3.90	4.00	54.0	55.0	101.54
860204	900	860211	930	1.727	1.000	4.30	4.30	22.0	23.0	50.03
860211	930	860218	905	2.170	2.700	4.00	4.10	44.0	38.0	89.80
860218	905	860225	845	1.240	2.200	4.20	4.20	26.0	23.0	91.55
860225	845	860304	715							
860304	715	860311	827	3.587	3.800	4.10	4.20	44.0	46.0	67.93
860311	827	860318	818	.841	1.600	4.40	4.30	20.0	21.0	76.63
860318	818	860325	835	3.853	5.000	4.20	4.10	49.0	48.0	88.34
860325	835	860401	920	4.429	5.400	3.90	3.90	62.0	58.0	114.67
860401	920	860408	845	5.314	5.200	3.90	3.80	77.0	81.0	102.05
860408	845	860415	850							
860415	850	860422	843	1.461	3.800	4.10	4.10	39.0	42.0	98.51
860422	843	860429	857	2.923	3.800	4.00	4.00	47.0	47.0	88.99
860429	857	860506	850	5.757	6.200	3.80	3.80	89.0	84.0	101.30
860506	850	860513	843	4.871	7.400	3.70	3.80	88.0	87.0	95.29
860513	843	860520	850							
860520	850	860527	855	1.329	1.600	4.40	4.40	23.0	22.0	97.96
860527	850	860603	825	4.163	7.200	4.00	4.00	62.0	50.0	94.73
860603	850	860610	855	2.347	3.300	4.10	4.10	39.0	65.0	95.51
860610	916	860617	920	1.506	2.300	4.20	4.20	29.0	38.0	98.25
860617	920	860624	943	5.314	4.900	3.90	3.90	70.0	70.0	78.02
860624	943	860701	930	4.871	7.700	3.70	3.70	90.0	90.0	96.86
860701	930	860708	932	.841	1.100	4.80	4.50	15.0	17.0	96.96
860708	932	860715	925	2.214	3.700	4.00	4.00	46.0	43.0	95.34
860715	925	860722	911							
860722	911	860729	905	2.037	2.600	4.20	4.10	36.0	36.0	89.63
860729	905	860805	913	3.897	5.700	3.80	3.80	74.0	78.0	99.81
860805	913	860812	851	.000	.000	3.70	3.70	88.0	92.0	94.06
860812	851	860819	931	2.170	2.500	4.20	4.10	35.0	36.0	95.30
860819	931	860826	919	1.151	1.300	4.40	4.30	20.0	20.0	97.85
860826	919	860902	937	2.746	5.400	3.90	3.90	58.0	62.0	91.64
860902	937	860909	918	.000	10.000	3.60	3.60	113.0	117.0	97.38
860909	918	860916	921	5.314	7.300	3.80	3.70	82.0	88.0	97.98
860916	920	860923	940	.000	8.300	3.60	3.60	108.0	0.0	77.37
860923	940	860930	927	3.011	4.200	3.90	3.90	54.0	53.0	96.15
860930	927	861007	925	4.251	4.300	3.90	3.90	60.0	61.0	75.79
861007	925	861014	925	.886	1.200	4.50	4.40	16.0	17.0	71.03
861014	925	861021	918							
861021	918	861028	705	1.639	1.700	4.40	4.20	21.0	28.0	89.82
861028	705	861104	604							
861104	604	861111	830	1.063	1.200	4.80	4.30	14.0	25.0	90.28
861111	830	861118	910							101.59
861118	910	861125	913	1.019	.700		4.50	9.0	14.0	98.51
861125	913	861202	902	.177	.400	6.30	4.80	3.0	7.0	97.81
861202	921	861209	1023	.576	.800	7.30	4.60	17.0	13.0	100.32
861209	910	861216	909	.000	1.300	5.80	6.50	13.0	19.0	87.50
861216	909	861223	927	.974	1.300	4.60	4.30	20.0	24.0	88.37
861223	927	861230	925	.576	1.000	6.60	4.60	8.0	14.0	98.28

Table B-2.-- Chemical data for Sampler A-2

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	900	860121	909	867.2	0.010	0.020	0.240	0.010	0.061	1.300
860121	909	860128	938	5882.2	.010	.030	.240	.020	.049	.460
860128	938	860204	905	755.9	.000	.000	.370	.050	.401	.570
860204	905	860211	934	1253.6	.160	.030	.360	.010	.061	.270
860211	934	860218	910	1246.1	.120	.040	.420	.010	.255	.390
860218	910	860225	849	3340.5	.080	.030	.130	.020	.134	.250
860225	849	860304	719	0						
860304	719	860311	831	273.1	.580	.130	.650	.110	1.336	1.100
860311	831	860318	822	3313.6	.040	.030	.210	.030	.121	.350
860318	822	860325	838	254.6	.700	.190	1.100	.110	.814	1.300
860325	838	860401	923	138.3	.570	.160	.220	.040	.716	.510
860401	923	860408	849	865.8	.320	.110	.420	.040	.571	1.000
860408	849	860415	853	0						
860415	853	860422	847	4087.6	.020	.030	.180	.010	.413	.320
860422	847	860429	900	1965.7	.100	.060	.110	.030	.522	.260
860429	900	860506	853	694.8	.380	.070	.120	.060	.850	.370
860506	853	860513	846	481.4	.380	.060	.100	.080	.777	.380
860513	846	860520	853	0						
860520	853	860527	905	2121.3	.070	.060	.410	.020	.158	-----
860527	905	860603	853	389.5	.880	.180	.010	.090	1.190	-----
860603	853	860610	912	5796.7	.170	.050	.100	.020	.267	.210
860610	912	860617	914	2952.1	.240	.020	.040	.030	.182	.130
860617	914	860624	932	256.3	.320	.040	.010	.010	.595	.270
860624	932	860701	925	1032.4	.240	.050	.070	.030	.765	.300
860701	925	860708	925	2684.7	.010	.020	.120	.020	.073	.170
860708	925	860715	923	3320.8	.020	.030	.040	.060	.206	.240
860715	923	860722	910	0						
860722	910	860729	908	3839.3	.020	.030	.060	.010	.219	.190
860729	908	860805	912	3886.8	.070	.030	.050	.030	.364	.260
860805	912	860812	850	164.5	.140	.040	.110	.070	.595	-----
860812	850	860819	929	679.9	.010	.040	.010	.130	.134	.190
860819	929	860826	916	1531.5	.010	.020	.010	.160	.036	.130
860826	916	860902	934	208.8	.100	.070	.010	.150	.316	.180
860902	934	860909	916	762.7	.050	.030	.090	.110	.680	.400
860909	916	860916	918	259.5	.160	.030	.060	.030	.899	.230
860916	918	860923	942	652.2	.140	.050	.150	.010	1.032	.500
860923	942	860930	925	593.5	.140	.040	.080	.010	.328	.240
860930	925	861007	921	1716.1	.100	.030	.130	.010	.279	.240
861007	921	861014	920	733.2	.070	.020	.080	.010	.085	.120
861014	920	861021	913	0						
861021	913	861028	703	1040.5	.070	.030	.090	.010	.170	.250
861028	703	861104	610	0						
861104	610	861111	833	2554.1	.040	.030	.100	.010	.073	.510
861111	833	861118	912	1275.7	.040	.010	.070	.010	.061	.410
861118	912	861125	916	5452.8	.060	.030	.130	.010	.097	.210
861125	916	861202	904	1675.9	.010	.000	.050	-----	.049	.150
861202	904	861209	1025	3356.5	.050	.040	.360	.010	.036	.600
861209	1025	861216	912	854.0	.020	.020	.040	.050	.109	.300
861216	912	861223	929	2721.2	.020	.050	.400	-----	.085	.920
861223	929	861230	927	2356.1	.020	.030	.220	.010	.170	.410

Table B-2.-- Chemical data for Sampler A-2 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	900	860121	909	1.329	1.200	4.200	4.100	35.000	35.000	89.81
860121	909	860128	938	.443	1.000	4.500	4.500	15.000	13.000	99.46
860128	938	860204	905	4.871	3.100	4.000	4.000	54.000	54.000	101.95
860204	905	860211	934	1.904	1.100	4.300	4.300	25.000	25.000	60.59
860211	934	860218	910	2.569	2.800	4.000	4.000	46.000	39.000	100.38
860218	910	860225	849	1.417	2.300	4.200	4.200	32.000	30.000	150.19
860225	849	860304	719							
860304	719	860311	831	5.757	5.800	3.900	3.900	73.000	70.000	98.99
860311	831	860318	822	1.151	2.000	4.300	4.300	25.000	27.000	88.97
860318	822	860325	838	3.853	5.000	4.200	4.200	50.000	47.000	92.29
860325	838	860401	923	4.871	5.800	3.900	3.900	62.000	58.000	114.59
860401	923	860408	849	5.757	5.300	3.800	3.800	78.000	84.000	96.57
860408	849	860415	853							
860415	853	860422	847	1.461	3.800	4.100	4.100	39.000	41.000	100.03
860422	847	860429	900	3.100	4.100	4.100	4.000	47.000	47.000	97.44
860429	900	860506	853	5.757	6.500	3.800	3.800	80.000	85.000	103.32
860506	853	860513	846	4.871	7.400	3.800	3.800	83.000	85.000	93.07
860513	846	860520	853							
860520	853	860527	905	1.373	1.700	4.400	4.500	24.000	23.000	100.02
860527	905	860603	853	4.119	7.400	4.000	3.900	62.000	57.000	94.12
860603	853	860610	912	2.524	3.200	4.100	4.100	40.000	74.000	96.05
860610	912	860617	914	1.506	2.400	4.200	4.200	29.000	38.000	100.12
860617	914	860624	932	5.757	5.100	3.800	3.800	74.000	74.000	78.23
860624	932	860701	925	4.871	7.700	3.700	3.700	90.000	92.000	99.79
860701	925	860708	925	.886	1.100	4.500	4.500	15.000	17.000	97.93
860708	925	860715	923	2.214	3.700	4.000	4.000	46.000	44.000	95.34
860715	923	860722	910							
860722	910	860729	908	2.037	2.600	4.200	4.100	35.000	37.000	94.75
860729	908	860805	912	3.897	5.600	3.800	3.800	74.000	78.000	100.64
860805	912	860812	850	-----	-----	3.800	3.800	82.000	85.000	86.73
860812	850	860819	929	1.771	2.200	4.200	4.100	30.000	32.000	96.18
860819	929	860826	916	1.151	1.300	4.300	4.300	20.000	20.000	98.69
860826	916	860902	934	2.657	5.500	3.900	3.900	57.000	61.000	93.15
860902	934	860909	916	-----	10.000	3.600	3.600	112.000	116.000	98.30
860909	916	860916	918	4.871	7.000	3.800	3.700	81.000	88.000	100.34
860916	918	860923	942	-----	7.600	3.600	3.700	100.000	103.000	94.56
860923	942	860930	925	2.746	3.800	4.000	4.000	48.000	48.000	95.61
860930	925	861007	921	3.321	3.400	4.000	4.000	47.000	49.000	91.31
861007	921	861014	920	.886	1.200	4.400	4.400	17.000	18.000	72.07
861014	920	861021	913							
861021	913	861028	703	1.639	1.700	4.400	4.200	22.000	29.000	90.07
861028	703	861104	610							
861104	610	861111	833	1.063	1.300	4.500	4.300	19.000	25.000	93.16
861111	833	861118	912	.531	.700	5.000	4.500	10.000	13.000	102.76
861118	912	861125	916	1.107	.700	4.800	4.500	11.000	14.000	103.35
861125	916	861202	904	.221	.400	5.900	4.800	4.000	6.000	100.20
861202	904	861209	1025	.576	.800	5.700	4.600	8.000	13.000	101.92
861209	1025	861216	912	1.151	1.300	5.800	4.300	17.000	20.000	93.45
861216	912	861223	929	.974	1.300	4.800	4.300	17.000	24.000	92.84
861223	929	861230	927	.576	1.000	5.800	4.600	8.000	14.000	100.48

Table B-3.-- Chemical data for Sampler A-3

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	910	860121	914	892.1	0.020	0.020	0.250	0.010	0.073	1.400
860121	914	860128	941	5771.9	.010	.030	.230	.030	.049	.430
860128	941	860204	914	756.3	.000	.000	.360	.050	.401	.550
860204	914	860211	942	1187.9	.080	.040	.180	.030	.061	.280
860211	942	860218	914	1190	.120	.040	.200	.020	.255	.400
860218	914	860225	856	2228.3	.080	.030	.110	.020	.146	.280
860225	856	860304	722	0						
860304	722	860311	840	284.8	.650	.140	.650	.110	1.336	1.100
860311	840	860318	827	3628.1	.040	.030	.150	.030	.146	.380
860318	827	860325	845	267.3	.730	.210	.650	.110	.886	1.500
860325	845	860401	927	136.4	.810	.210	.390	.070	1.081	.710
860401	927	860408	855	1031	.350	.120	.430	.040	.583	1.100
860408	855	860415	857	0						
860415	857	860422	855	4121.3	.020	.030	.200	.020	.425	.330
860422	855	860429	910	1842	.120	.060	.120	.030	.510	.270
860429	910	860506	904	691.4	.410	.070	.080	.080	.923	.370
860506	904	860513	854	485.9	.460	.070	.110	.100	.862	.410
860513	854	860520	902	0						
860520	902	860527	909	2108.5	.100	.080	.500	.100	.498	-----
860527	909	860603	904	394.9	.930	.190	.010	.090	1.178	-----
860603	904	860610	908	5827.3	.170	.050	.130	.120	.704	.230
860610	908	860617	909	2932.8	.070	.020	.030	.020	.170	.130
860617	909	860624	928	302.9	.300	.040	.010	.010	.571	.280
860624	928	860701	920	1025.0	.240	.050	.040	.030	.753	.300
860701	920	860708	920	2726.5	.010	.020	.140	.020	.097	.170
860708	920	860715	915	3420.4	.020	.030	.040	.030	.194	.240
860715	915	860722	908	0						
860722	908	860729	912	3819.3	.020	.030	.060	.010	.206	.190
860729	912	860805	910	3849.9	.090	.040	.070	.100	.449	.260
860805	910	860812	848	184.7	.180	.050	.150	.100	.631	-----
860812	848	860819	926	693.8	.020	.060	.060	-----	.036	.350
860819	926	860826	914	1568.6	.010	.020	.010	.150	.036	.130
860826	914	860902	932	219.0	.010	.010	.010	.210	.243	.190
860902	932	860909	912	771.4	.070	.040	.110	.120	.704	.400
860909	912	860916	915	267.3	.140	.030	.050	.040	.838	.230
860916	915	860923	944	680.2	.140	.050	.150	.020	1.044	.400
860923	944	860930	923	620.8	.170	.040	.100	-----	-----	.400
860930	923	861007	918	1774.0	.070	.030	.130	.010	.279	.230
861007	918	861014	916	596.2	.040	.020	.110	.020	.061	.120
861014	916	861021	909	0						
861021	909	861028	657	1113.1	-----	-----	-----	-----	-----	-----
861028	657	861104	612	0						
861104	612	861111	836	2631.2	.040	.030	.100	.010	.085	.520
861111	836	861118	915	1277.5	.040	.010	.070	.010	.061	.420
861118	915	861125	918	5204.2	.060	.030	.110	.010	.097	.240
861125	918	861202	905	1655.3	.000	-----	.090	-----	.073	.180
861202	905	861209	910	3414.3	.050	.050	.370	.010	.036	.620
861209	910	861216	918	437.2	.020	.000	.040	-----	.073	.170
861216	918	861223	930	2596.4	.020	.050	.450	-----	.085	.950
861223	930	861230	930	2392.6	.020	.030	.230	.010	.170	.420

Table B-3.-- Chemical data for Sampler A-3 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	910	860121	914	1.506	1.300	4.100	4.100	38.000	36.000	92.39
860121	914	860128	941	.487	1.000	4.500	4.600	15.000	13.000	97.60
880128	941	860204	914	4.871	3.000	3.900	4.000	53.000	55.000	102.01
860204	914	860211	942	1.949	1.100	4.300	4.300	24.000	25.000	57.41
880211	942	860218	914	2.657	2.800	4.000	4.000	44.000	42.000	95.86
860218	914	860225	856	1.461	2.500	4.100	4.200	48.000	31.000	100.18
860225	856	880304	722							
860304	722	860311	840	6.200	6.200	3.900	3.900	75.000	68.000	103.24
860311	840	860318	827	1.240	2.100	4.300	4.300	27.000	28.000	97.42
860318	827	860325	845	4.074	5.400	4.100	4.100	52.000	52.000	96.89
860325	845	860401	927	6.643	7.800	3.800	3.900	86.000	73.000	113.01
860401	927	860408	855	5.757	5.700	3.800	3.800	82.000	87.000	114.99
860408	855	860415	857							
860415	857	860422	855	1.594	4.000	4.100	4.100	41.000	43.000	100.85
880422	855	860429	910	3.100	4.000	4.000	4.100	49.000	48.000	91.31
860429	910	860506	904	6.200	6.900	3.800	3.800	86.000	90.000	102.82
860506	904	860513	854	4.871	7.900	3.700	3.800	90.000	89.000	93.94
860513	854	860520	902							
860520	902	860527	909	1.461	2.000	4.600	4.600	21.000	21.000	99.42
860527	909	860603	904	4.207	7.300	4.000	4.000	64.000	51.000	95.43
860603	904	860610	908	2.613	3.600	4.200	4.200	33.000	66.000	96.56
860610	908	860617	909	1.594	2.500	4.200	4.200	31.000	35.000	99.47
860617	909	860624	928	6.200	5.300	3.800	3.900	75.000	71.000	92.46
860624	928	860701	920	5.314	7.900	3.700	3.700	90.000	89.000	99.08
860701	920	860708	920	.930	1.200	4.500	4.400	16.000	18.000	99.45
860708	920	860715	915	2.303	3.800	4.000	4.000	47.000	46.000	98.20
860715	915	860722	908							
860722	908	860729	912	2.081	2.700	4.100	4.100	35.000	37.000	94.26
860729	912	860805	910	3.986	5.800	3.800	9.990	68.000	.000	99.68
860805	910	860812	848	-----	-----	3.700	3.700	95.000	98.000	97.38
860812	848	860819	926	1.949	2.500	4.200	4.100	32.000	31.000	98.14
860819	926	860826	914	1.151	1.300	4.400	4.300	21.000	20.000	101.08
860826	914	860902	932	2.834	5.600	3.900	3.900	60.000	63.000	97.70
860902	932	860909	912	-----	10.000	3.600	3.600	120.000	121.000	99.42
860909	912	860916	915	4.871	6.700	3.800	3.800	79.000	84.000	103.35
860916	915	860923	944	-----	7.800	3.600	3.700	102.000	107.000	98.62
860923	944	860930	923	3.056	5.000	9.990	4.900	43.000	27.000	100.01
860930	923	861007	918	3.277	3.300	4.000	4.000	47.000	48.000	94.39
861007	918	861014	916	.797	1.200	4.500	4.400	15.000	16.000	58.60
861014	916	861021	909							
861021	909	861028	657	-----	-----	-----	-----	-----	-----	96.35
861028	657	861104	612							
861104	612	861111	836	1.151	1.400	4.400	4.200	21.000	27.000	95.98
861111	836	861118	915	.576	.700	4.800	4.400	12.000	14.000	102.90
861118	915	861125	918	1.063	.700	4.700	4.500	12.000	15.000	98.64
861125	918	861202	905	.354	.700	5.400	4.800	6.000	9.000	98.97
861202	905	861209	910	.620	.780	5.400	4.500	8.000	13.000	103.68
861209	910	861216	918	1.639	1.800	4.900	4.200	15.000	28.000	47.84
861216	918	861223	930	.974	1.200	4.500	4.300	18.000	24.000	88.58
861223	930	861230	930	.576	1.000	5.300	4.600	8.000	14.000	102.03

Table B-4.-- Chemical data for Sampler G-4

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	918	860121	923	534.4	0.010	0.020	0.240	0.010	0.061	0.950
860121	923	860128	950	4030.1	.010	.030	.320	.020	.049	.570
860128	950	860204	923	63.8						
860204	923	860211	950	797.3	.120	.040	.460	.030	.073	.260
860211	950	860218	922	0						
860218	922	860225	910	424.5	.120	.030	.360	.030	.316	.540
860225	910	860304	728	0						
860304	728	860311	847	235	.550	.120	.650	.100	1.214	1.000
860311	847	860318	835	2929.5	.020	.020	.100	.020	.134	.330
860318	835	860325	853	130.9	.730	.170	1.200	.090	.862	.850
860325	853	860401	938	94.3	.510	.140	.250	.050	.741	.480
860401	938	860408	902	300.1	.320	.110	.560	.040	.546	1.100
860408	902	860415	905	0						
860415	905	860422	903	2687.9	.010	.030	.290	.010	.352	.300
860422	903	860429	917	1274.7	.070	.050	.100	.030	.522	.250
860429	917	860506	913	561.5	.240	.050	.070	.050	.704	.330
860506	913	860513	902	387.7	.460	.060	.100	.080	.886	.360
860513	902	860520	910	0						
860520	910	860527	915	1685.1	.010	.050	.340	.020	.158	-----
860527	915	860603	910	286.3	.880	.170	.010	.100	1.214	-----
860603	910	860610	900	5039.2	.140	.040	.080	.010	.255	.190
860610	900	860617	905	2509.7	.140	.020	.030	.020	.194	.130
860617	905	860624	918	200.2	.300	.040	.010	.020	.619	.290
860624	918	860701	910	959.8	.220	.050	.040	.030	.729	.290
860701	910	860708	911	2385.7	.010	.010	.100	.010	.073	.150
860708	911	860715	910	3021.7	.020	.030	.030	.050	.194	.240
860715	910	860722	904	0						
860722	904	860729	905	3432.4	.040	.030	.050	.010	.206	.200
860729	905	860805	855	0						
860805	855	860812	845	107.3	.160	.050	.180	.150	.680	-----
860812	845	860819	921	576.4	.010	.040	.010	.140	.097	.170
860819	921	860826	910	1179.5	.010	.020	.010	.130	.036	.120
860826	910	860902	930	138.4	-----	-----	-----	-----	-----	-----
860902	930	860909	921	678.2	.090	.040	.090	.120	.668	.400
860909	921	860916	910	189.3	.110	.030	.060	.050	.971	.230
860916	910	860923	947	593.6	.120	.040	.140	.020	1.056	.400
860923	947	860930	918	461.3	.140	.040	.060	.010	.340	.160
860930	918	861007	912	1291.0	.120	.030	.100	.010	.279	.210
861007	912	861014	914	807.5	.040	.020	.100	.010	.085	.150
861014	914	861021	907	0						
861021	907	861028	650	1343.8	.100	.030	.070	.020	.304	.240
861028	650	861104	618	0						
861104	618	861111	840	1505.5	.040	.030	.090	.010	.061	.490
861111	840	861118	920	1107.6	.040	.010	.080	.010	.073	.470
861118	920	861125	925	637.6	.080	.040	.120	.050	.182	.190
861125	925	861202	908	845.4	.040	.010	.120	-----	.073	.230
861202	908	861209	910							
861209	910	861216	920	427.4	.050	.020	.060	-----	.121	.400
861216	920	861223	932	2329.5	.000	.050	.390	.010	.073	.850
861223	932	861230	932	2318.4	.000	.020	.200	.010	.158	.330

Table B-4.-- Chemical data for Sampler G-4 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	918	860121	923	1.063	1.200	4.200	4.200	32.000	29.000	55.34
860121	923	860128	950	.487	.800	4.600	4.800	14.000	12.000	68.14
860128	950	860204	923							
860204	923	860211	950	1.639	1.200	4.400	4.300	22.000	23.000	38.53
860211	950	860218	922							
860218	922	860225	910	2.126	3.700	4.000	4.000	26.000	48.000	19.08
860225	910	860304	728							
860304	728	860311	847	4.871	5.400	4.000	4.000	62.000	65.000	85.18
860311	847	860318	835	1.019	1.900	4.400	4.300	24.000	25.000	78.66
860318	835	860325	853	3.233	3.900	4.400	4.300	34.000	38.000	47.45
860325	853	860401	938	4.296	5.300	4.000	4.000	56.000	61.000	78.13
860401	938	860408	902	6.200	5.400	3.800	3.800	83.000	85.000	33.47
860408	902	860415	905							
860415	905	860422	903	1.329	3.600	4.200	4.100	35.000	38.000	65.77
860422	903	860429	917	3.189	4.200	4.000	4.000	48.000	50.000	63.19
860429	917	860506	913	6.200	5.800	3.800	3.800	72.000	76.000	83.50
860506	913	860513	902	4.429	7.300	3.700	3.800	86.000	80.000	74.95
860513	902	860520	910							
860520	910	860527	915	1.151	1.500	4.600	4.400	21.000	21.000	79.46
860527	915	860603	910	4.030	7.500	3.900	3.800	70.000	59.000	69.18
860603	910	860610	900	2.391	3.100	4.100	4.100	37.000	77.000	83.50
860610	900	860617	905	1.329	2.200	4.300	4.300	26.000	35.000	85.12
860617	905	860624	918	5.314	5.100	3.900	3.900	70.000	71.000	61.11
860624	918	860701	910	4.871	7.500	3.800	.000	85.000	.000	92.78
860701	910	860708	911	.753	1.000	4.500	4.500	14.000	15.000	87.02
860708	911	860715	910	2.303	3.800	4.000	4.000	48.000	44.000	86.76
860715	910	860722	904							
860722	904	860729	905	1.949	2.500	4.200	4.100	34.000	36.000	84.71
860729	905	860805	855							
860805	855	860812	845	-----	-----	3.800	3.800	73.000	77.000	56.57
860812	845	860819	921	1.373	1.900	4.300	4.200	24.000	26.000	81.53
860819	921	860826	910	.886	1.200	4.500	4.400	20.000	17.000	76.01
860826	910	860902	930	-----	-----	-----	-----	-----	-----	61.74
860902	930	860909	921	-----	10.000	3.600	3.600	106.000	107.000	87.41
860909	921	860916	910	4.429	6.500	3.800	3.800	74.000	81.000	73.19
860916	910	860923	947	-----	7.300	3.700	3.700	96.000	103.000	86.07
860923	947	860930	918	2.214	3.500	4.100	4.100	41.000	40.000	74.32
860930	918	861007	912	2.967	3.000	4.000	4.000	43.000	43.000	68.69
861007	912	861014	914	.974	1.400	4.500	4.400	18.000	19.000	79.38
861014	914	861021	907							
861021	907	861028	650	1.949	2.500	4.300	4.200	27.000	36.000	116.32
861028	650	861104	618							
861104	618	861111	840	.797	1.100	4.500	4.300	18.000	22.000	54.91
861111	840	861118	920	.576	.700	4.800	4.400	12.000	14.000	89.22
861118	920	861125	925	2.214	1.200	4.400	4.300	22.000	24.000	12.08
861125	925	861202	908	.531	1.200	5.000	4.500	10.000	15.000	50.54
861202	908	861209	910							
861209	910	861216	920	.886	.970	4.800	4.400	13.000	16.000	46.77
861216	920	861223	932	.974	1.100	4.400	4.400	18.000	23.000	79.47
861223	932	861230	932	.531	.900	5.200	4.600	9.000	13.000	98.87

Table B-5.-- Chemical data for Sampler A-5

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	925	860121	930	699.9	0.010	0.020	0.250	0.010	0.061	1.400
860121	930	860128	930	5872	.010	.020	.220	.010	.049	.440
860128	930	860204	930	855.2	.000	.000	.340	.040	.328	.510
860204	930	860211	1005	166.2	.100	.030	.360	.040	.061	.250
860211	1005	860218	930	1153.6	.100	.040	.340	.020	.231	.320
860218	930	860225	920	2099.0	.060	.030	.160	.020	.121	.160
860225	920	860304	738	0						
860304	738	860311	855	224.9	.410	.110	.580	.090	1.020	.900
860311	855	860318	848	3619.7						
860318	848	860325	902	292.3	.700	.200	.660	.100	.838	1.500
860325	902	860401	945	139.7	-----	-----	-----	-----	-----	-----
860401	945	860408	912	1028.4	.320	.120	.470	.040	.559	1.100
860408	912	860415	915	0						
860415	915	860422	915	4196.9	.020	.030	.190	.020	.413	.340
860422	915	860429	925	2119.5	.120	.060	.120	.030	.546	.270
860429	925	860506	930	715.1	.570	.080	.160	.150	.935	.500
860506	930	860513	915	497.8	.430	.060	.110	.070	.741	.400
860513	915	860520	925	0						
860520	925	860527	921	2205.2	.040	.070	.430	.020	.170	-----
860527	921	860603	925	398.6	.960	.190	.010	.160	1.154	-----
860603	925	860610	925	5105.9	.170	.050	.090	.030	.267	.210
860610	925	860617	930	3055.0	.170	.020	.030	.020	.170	.130
860617	930	860624	947	304.4	.390	.040	.010	.020	.571	.280
860624	947	860701	940	1032.5	.240	.050	.050	.300	.741	.300
860701	940	860708	927	2724.0	.010	.020	.090	.010	.073	.170
860708	927	860715	930	3446.6	.020	.030	.030	.070	.219	.320
870715	930	860722	913	0						
860722	913	860729	911	3518.2	.400	.190	.060	.010	.304	.220
860729	911	860805	915	3945.7	.070	.030	.060	.060	.364	.260
860805	915	860812	853	190.2	.180	.050	.120	.160	.607	-----
860812	853	860819	914	704.3	.010	.040	.010	.190	.158	.220
860819	914	860826	921	1541.6	.010	.020	.010	.120	.024	.120
860826	921	860902	941	212.7	.160	.070	.040	.260	.279	.220
860902	941	860909	921	786.9	.070	.040	.120	.120	.741	.500
860909	921	860916	930	273.6	.160	.030	.090	.040	.674	.240
860916	930	860923	951	679.0	.170	.050	.160	.010	1.081	.400
860923	951	860930	915	623.4	.140	.040	.090	.020	.401	.400
860930	915	861007	910	1799.5	.100	.030	.120	.010	.304	.230
861007	910	861014	910	834.6	.040	.030	.100	.010	.085	.140
861014	910	861021	903	0						
861021	903	861028	646	2230.0	.070	.030	.060	.020	.194	.250
861028	646	861104	600	0						
861104	600	861111	845	2662.4	.020	.030	.110	.010	.085	.510
861111	845	861118	905	1276.2	.040	.010	.090	.010	.061	.410
861118	905	861125	910	5623.9	.040	.030	.150	.020	.097	.230
861125	910	861202	900	1710.0	.010	.010	.080	-----	.097	.170
861202	900	861209	1020	3469.7	.020	.040	.400	.040	.049	.630
861209	1020	861216	858	928.6	.020	.020	.070	-----	.121	.320
861216	858	861223	925	2800.5	.020	.050	.440	.010	.073	.960
861223	925	861230	923	2380.4	.020	.030	.220	.010	.170	.410

Table B-5.-- Chemical data for Sampler A-5 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	925	860121	930	1.151	1.100	4.100	4.100	34.000	34.000	72.48
860121	930	860128	930	.443	.900	4.600	4.700	14.000	13.000	99.29
860128	930	860204	930	4.429	2.800	4.000	4.000	53.000	51.000	115.35
860204	930	860211	1005	1.683	1.000	4.300	4.300	21.000	22.000	8.03
860211	1005	860218	930	2.170	2.700	4.100	4.100	40.000	38.000	92.92
860218	930	860225	920	1.151	1.600	4.200	4.300	35.000	24.000	94.37
860225	920	860304	738							
860304	738	860311	855	4.207	4.400	4.100	4.100	54.000	52.000	81.52
860311	855	860318	848							97.19
860318	848	860325	902	4.030	5.400	4.200	4.100	52.000	51.000	105.95
860325	902	860401	945	-----	-----	-----	-----	-----	-----	115.75
860401	945	860408	912	5.314	5.600	3.800	3.800	78.000	84.000	114.70
860408	912	860415	915							
860415	915	860422	915	1.550	4.000	4.100	4.100	40.000	43.000	102.70
860422	915	860429	925	3.144	4.100	4.100	4.000	48.000	47.000	105.06
860429	925	860506	930	6.200	6.600	3.800	3.800	80.000	84.000	106.34
860506	930	860513	915	4.871	7.600	3.800	3.800	82.000	88.000	96.24
860513	915	860520	925							
860520	925	860527	921	1.373	1.700	4.400	4.400	24.000	24.000	103.98
860527	921	860603	925	4.119	7.200	4.000	4.000	63.000	51.000	96.32
860603	925	860610	925	2.524	3.300	4.100	4.100	40.000	67.000	84.61
860610	925	860617	930	1.550	2.400	4.200	4.200	30.000	39.000	103.61
860617	930	860624	947	5.757	5.100	3.800	3.800	74.000	72.000	92.92
860624	947	860701	940	5.314	7.900	3.700	9.990	92.000	.000	99.80
860701	940	860708	927	.886	1.100	4.500	4.400	16.000	18.000	99.36
860708	927	860715	930	2.303	3.800	4.000	4.000	49.000	47.000	98.96
860715	930	860722	913							
860722	913	860729	911	2.657	3.600	4.100	4.100	47.000	37.000	86.83
860729	911	860805	915	3.986	5.700	3.800	3.800	74.000	82.000	102.16
860805	915	860812	853	-----	-----	3.700	3.700	93.000	96.000	100.28
860812	853	860819	914	1.993	2.300	4.200	4.100	32.000	34.000	99.63
860819	914	860826	921	1.107	1.300	4.400	4.400	18.000	20.000	99.34
860826	921	860902	941	2.879	5.500	4.000	3.900	60.000	63.000	94.89
860902	941	860909	921	-----	11.000	3.600	3.600	120.000	119.000	101.42
860909	921	860916	930	4.871	6.800	3.700	3.700	83.000	86.000	105.79
860916	930	860923	951	-----	7.900	3.600	3.700	102.000	108.000	98.45
860923	951	860930	915	3.011	4.100	4.000	3.900	52.000	51.000	100.43
860930	915	861007	910	3.321	3.300	4.000	.000	49.000	49.000	95.75
861007	910	861014	910	.930	1.300	4.400	4.400	17.000	18.000	82.04
861014	910	861021	903							
861021	903	861028	646	1.860	1.900	4.400	4.200	23.000	31.000	193.04
861028	646	861104	600							
861104	600	861111	845	1.107	1.300	4.400	4.300	22.000	26.000	97.11
861111	845	861118	905	.531	.700	4.800	4.500	11.000	13.000	102.80
861118	905	861125	910	1.107	.700	4.700	4.500	13.000	14.000	106.59
861125	910	861202	900	.354	.600	5.200	4.700	6.000	9.000	102.24
861202	900	861209	1020	.576	.800	5.200	4.500	9.000	13.000	105.36
861209	1020	861216	858	1.240	1.400	4.600	4.300	19.000	22.000	101.62
861216	858	861223	925	1.019	1.300	4.400	4.300	19.000	24.000	95.54
861223	925	861230	923	.576	1.000	5.000	4.600	10.000	14.000	101.51

Table B-6.-- Chemical data for Sampler A-6

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	955	860121	1020	722.3	0.010	0.020	0.270	0.010	0.073	1.400
860121	1020	860128	1045	5951.6	.010	.020	.190	.030	.049	.380
860128	1045	860204	1000	760.6	.000	.000	.310	.050	.389	.490
860204	1000	860211	1030	1428.9	.080	.040	.490	.010	.061	.280
860211	1030	860218	958	1389.4	.120	.040	.380	.020	.267	.480
860218	958	860225	940	2152.7	.080	.030	.150	.010	.146	.370
860225	940	860304	755	0						
860304	755	860311	920	293.9	.650	.120	.620	.100	1.579	1.000
860311	920	860318	915	3633.9						
860318	915	860325	930	514.1	.380	.130	1.300	.080	.789	.780
860325	930	860401	1005	149.7	.590	.130	.280	.060	.826	.520
860401	1005	860408	930	1057.5	.290	.110	.460	.040	.546	.980
860408	930	860415	940	0						
860415	940	860422	947	4912.7	.020	.030	.440	.010	.376	.320
860422	947	860429	945	2342.6	.050	.020	.090	.020	.461	.220
860429	945	860506	955	1156.4	.380	.080	.080	.080	.753	.330
860506	955	860513	940	419.4	.430	.060	.110	.080	.838	.350
860513	940	860520	948	0						
860520	948	860527	930	2043.5	.010	.050	.350	.010	.158	-----
860527	930	860603	945	334.6	.930	.190	.050	.130	1.202	-----
860603	945	860610	938	5916.0	.220	.040	.080	.020	.194	.210
860610	938	860617	935	2691.1	.190	.020	.040	.020	.182	.130
860617	935	860624	1026	672.4	.260	.020	.010	.040	.486	.230
860624	1026	860701	1005	1535.4	.140	.040	.050	.020	.546	.230
860701	1005	860708	945	2522.2	.010	.020	.080	.030	.061	.120
860708	945	860715	1000	3426.5	.020	.030	.030	.080	.219	.240
860715	1000	860722	1025	0						
860722	1025	860729	1035	3739.4	.040	.030	.050	.020	.194	.190
860729	1035	860805	1104	2843.1	.090	.030	.050	.040	.461	.340
860805	1104	860812	1045	197.0	.180	.040	.100	.100	.668	.400
860812	1045	860819	1004	699.9	.010	.060	.010	.120	.194	.200
860819	1004	860826	1010	1575.0	.010	.020	.010	.100	.036	.160
860826	1010	860902	1030	178.7	.080	.040	.080	.240	.267	.270
860902	1030	860909	1036	958.4	.070	.040	.100	.100	.474	.370
860909	1036	860916	1015	327.9	.140	.030	.070	.040	.935	.220
860916	1015	860923	1035	601.2	.140	.040	.140	.020	.935	.400
860923	1035	860930	1015	840.5	.140	.040	.070	.020	.486	.230
860930	1015	861007	1030	1870.5	.100	.030	.080	.010	.219	.220
861007	1030	861014	946	784.9	.040	.020	.070	.010	.049	.120
861014	946	861021	939	0						
861021	939	861028	740	2266.8	.020	.030	.090	.020	.134	.600
861028	740	861104	655	0						
861104	655	861111	1045	2834.0	.040	.030	.100	.010	.085	.210
861111	1045	861118	945	972.2	.040	.010	.080	.010	.049	.150
861118	945	861125	950	4322.3	.040	.030	.070	.010	.134	.170
861125	950	861202	1015	1766.3	.010	.000	.080	-----	.049	.160
861202	1015	861209	1150	2166.0	.050	.050	.430	.020	.049	.680
861209	1150	861216	930	302.1	.170	.040	.290	-----	.158	.460
861216	930	861223	950	2728.3	.020	.040	.370	-----	.073	.680
861223	950	861230	943	2285.8	.000	.030	.250	.010	.206	.440

Table B-6.-- Chemical data for Sampler A-6 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	955	860121	1020	1.329	1.300	4.100	4.200	36.000	36.000	74.80
860121	1020	860128	1045	.443	.900	4.600	4.600	14.000	13.000	100.63
860128	1045	860204	1000	4.871	2.900	4.000	4.000	53.000	54.000	102.59
860204	1000	860211	1030	1.727	1.000	4.300	4.300	23.000	23.000	69.06
860211	1030	860218	958	2.746	2.900	4.000	4.100	45.000	43.000	111.92
860218	958	860225	940	1.417	2.400	4.100	4.200	31.000	32.000	96.78
860225	940	860304	755							
860304	755	860311	920	6.200	6.600	3.900	3.900	80.000	77.000	106.53
860311	920	860318	915							97.57
860318	915	860325	930	2.524	3.700	4.400	4.300	33.000	34.000	186.36
860325	930	860401	1005	4.871	5.400	9.990	4.000	63.000	54.000	124.03
860401	1005	860408	930	5.314	5.600	3.800	3.800	76.000	80.000	117.95
860408	930	860415	940							
860415	940	860422	947	1.417	3.600	4.200	4.100	38.000	40.000	120.22
860422	947	860429	945	2.790	3.500	4.100	4.100	42.000	41.000	116.12
860429	945	860506	955	4.871	4.600	4.000	4.000	60.000	61.000	171.97
860506	955	860513	940	5.314	7.900	3.700	3.800	93.000	90.000	81.08
860513	940	860520	948							
860520	948	860527	930	1.151	1.500	4.500	4.500	20.000	20.000	96.36
860527	930	860603	945	4.384	7.900	3.900	4.100	66.000	36.000	80.86
860603	945	860610	938	2.170	2.600	4.100	4.100	35.000	47.000	98.03
860610	938	860617	935	1.594	2.500	4.200	4.100	31.000	33.000	91.27
860617	935	860624	1026	3.853	4.800	3.900	3.900	62.000	62.000	205.25
860624	1026	860701	1005	3.543	6.100	3.900	3.900	68.000	69.000	148.42
860701	1005	860708	945	.797	1.000	4.600	4.500	14.000	15.000	92.00
860708	945	860715	1000	2.303	3.700	4.000	4.000	47.000	47.000	98.38
860715	1000	860722	1025							
860722	1025	860729	1035	2.081	2.700	4.200	9.990	37.000	37.000	92.29
860729	1035	860805	1104	4.429	6.200	3.800	3.700	82.000	90.000	73.61
860805	1104	860812	1045	-----	10.000	3.700	3.700	100.000	103.000	103.87
860812	1045	860819	1004	2.303	3.300	4.100	4.000	41.000	43.000	99.01
860819	1004	860826	1010	1.063	1.100	4.400	4.300	18.000	18.000	101.5
860826	1010	860902	1030	3.809	5.900	3.800	3.800	73.000	76.000	79.72
860902	1030	860909	1036	4.207	7.000	3.700	3.700	84.000	85.000	123.52
860909	1036	860916	1015	4.340	6.400	3.800	3.800	72.000	77.000	126.78
860916	1015	860923	1035	-----	7.700	3.700	3.700	98.000	104.000	87.17
860923	1035	860930	1015	2.790	4.200	4.000	4.000	48.000	48.000	135.41
860930	1015	861007	1030	2.923	2.800	4.100	4.000	42.000	43.000	99.53
861007	1030	861014	946	.753	1.100	4.500	4.400	16.000	16.000	77.15
861014	946	861021	939							
861021	939	861028	740	1.461	1.500	4.400	4.200	23.000	31.000	196.23
861028	740	861104	655							
861104	655	861111	1045	1.151	1.400	4.500	4.300	18.000	22.000	103.37
861111	1045	861118	945	.266	.700	5.000	4.600	8.000	9.000	78.31
861118	945	861125	950	1.107	.700	4.800	4.500	11.000	12.000	81.92
861125	950	861202	1015	.310	.600	5.200	4.700	5.000	5.000	105.81
861202	1015	861209	1150	.576	.800	5.100	4.500	9.000	13.000	65.77
861209	1150	861216	930	2.701	2.900	4.300	4.000	36.000	41.000	33.06
861216	930	861223	950	.930	1.200	4.500	4.400	15.000	20.000	93.08
861223	950	861230	943	.664	1.100	5.100	4.500	10.000	10.000	97.48

Table B-7.-- Chemical data for Sampler V-7

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	915	860121	918	855.8	0.010	0.020	0.240	0.020	0.073	1.300
860121	918	860128	945	5720.6	.010	.030	.240	.020	.049	.440
860128	945	860204	919	728.5	.000	.000	.310	.050	.376	.510
860204	919	860211	945	1868.4	.160	.030	.230	.010	.036	.210
860211	945	860218	918	1101	.100	.040	.230	.010	.255	.380
860218	918	860225	905	2108.2	.060	.040	.110	.010	.134	.230
860225	905	860304	733	0						
860304	733	860311	844	263.7	.600	.130	.620	.110	1.336	1.100
860311	844	860318	631	3558.3	.040	.030	.140	.030	.134	.370
860318	831	860325	850	199.9	.980	.260	1.100	.140	1.105	1.800
860325	850	860401	935	94.5	1.000	.270	.490	.090	1.457	.760
860401	935	860408	858	1026.1	.320	.120	.490	.050	.571	1.100
860408	858	860415	902	0						
860415	902	860422	858	4054	.050	.040	.270	.040	.425	.330
860422	858	860429	914	1813.1	.120	.070	.130	.040	.559	.290
860429	914	860506	909	672	.410	.070	.090	.090	.984	.400
860506	909	860513	858	510	.430	.060	.110	.080	.862	.400
860513	858	860520	906	0						
860520	906	860527	912	2069	.070	.080	.500	.020	.194	-----
860527	912	860603	905	188.7						
860603	905	860610	904	5484.6	.580	.110	.250	.340	1.821	.310
860610	904	860617	900	2922.5	.140	.020	.040	.010	.194	.160
860617	900	860624	923	297.5	.330	.030	.010	.040	.546	.260
860624	923	860701	915	1050.1	.240	.050	.050	.030	.692	.300
860701	915	860708	914	2652	.100	.020	.100	.020	.097	.170
860708	914	860715	912	3418.8	.020	.030	.030	.080	.219	.240
860715	912	860722	906	0						
860722	906	860729	910	3804.7	.090	.030	.060	.030	.206	.200
860729	910	860805	900	3792.9	.090	.030	.070	.050	.376	.260
860805	900	860812	847	182.3	.180	.040	.130	.180	.680	.400
860812	847	860819	923	715.9	.010	.040	.010	.160	.134	.210
860819	923	860826	912	1545.5	.010	.020	.020	.160	.049	.120
860826	912	860902	931	216.1	.160	.070	.670	.320	.376	.400
860902	931	860909	914	742.7	.190	.060	.230	.160	.753	.600
860909	914	860916	912	254.5	.200	.040	.190	.100	.971	.320
860916	912	860923	949	684.6	.190	.050	.190	.030	1.093	.400
860923	949	860930	921	610.8	.170	.050	.120	.020	.389	.310
860930	921	861007	915	1746.7	.100	.030	.140	.020	.304	.230
861007	915	861014	918	827.9	.070	.030	.120	.010	.085	.150
861014	918	861021	911	0						
861021	911	861028	620	2236	.050	.030	.100	.020	.194	.250
861028	620	861104	620	0						
861104	620	861111	838	2565	.060	.030	.110	.010	.097	.210
861111	838	861118	918	1267.4	.040	.010	.070	.010	.073	.440

Table B-7.-- Chemical data for Sampler V-7 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	915	860121	918	1.461	1.300	4.100	4.100	37.000	36.000	88.63
860121	918	860128	945	.531	1.000	4.600	4.600	15.000	13.000	96.73
860128	945	860204	919	4.871	3.000	4.000	4.000	53.000	54.000	98.26
860204	919	860211	945	1.771	.800	4.400	4.300	20.000	21.000	90.30
860211	945	860218	918	2.569	3.000	4.000	4.000	42.000	42.000	88.69
860218	918	860225	905	1.329	2.300	4.200	4.200	31.000	28.000	94.78
860225	905	860304	733							
860304	733	860311	844	5.757	5.800	3.900	3.900	74.000	67.000	95.59
860311	844	860318	831	1.196	2.000	4.300	4.200	26.000	27.000	95.54
860318	831	860325	850	5.757	7.500	4.000	4.000	72.000	66.000	72.46
860325	850	860401	935	4.871	5.600	3.800	3.800	114.000	89.000	78.30
860401	935	860408	858	5.757	6.200	3.800	3.800	85.000	90.000	114.44
860408	858	860415	902							
860415	902	860422	858	1.639	4.100	4.100	4.100	42.000	44.000	99.21
860422	858	860429	914	3.499	4.700	4.000	4.000	52.000	55.000	89.88
860429	914	860506	909	6.643	7.300	3.800	3.800	90.000	93.000	99.93
860506	909	860513	858	4.871	7.600	3.700	3.800	93.000	86.000	98.60
860513	858	860520	906							
860520	906	860527	912	1.683	2.200	4.300	4.300	29.000	29.000	97.56
860527	912	860603	905	-----	-----	-----	-----	-----	-----	45.60
860603	905	860610	904	2.967	4.100	4.200	4.700	24.000	21.000	90.88
860610	904	860617	900	1.771	2.700	4.100	4.200	34.000	26.000	99.12
860617	900	860624	923	6.200	5.200	3.800	3.800	75.000	74.000	90.81
860624	923	860701	915	5.314	7.900	3.700	3.700	91.000	91.000	101.50
860701	915	860708	914	.930	1.200	4.500	4.400	17.000	18.000	96.73
860708	914	880715	912	2.303	3.700	4.000	4.000	47.000	47.000	98.16
860715	912	860722	906							
860722	906	860729	910	2.081	2.700	4.200	4.100	36.000	37.000	93.90
860729	910	860805	900	4.030	5.800	3.800	3.800	75.000	80.000	98.20
860805	900	860812	847	-----	9.900	3.700	3.700	100.000	105.000	96.12
860812	847	860819	923	2.037	2.500	4.200	4.100	34.000	35.000	101.27
860819	923	880826	912	1.107	1.300	4.400	4.400	20.000	19.000	99.59
860826	912	860902	931	2.967	5.800	4.000	4.000	54.000	57.000	96.41
860902	931	860909	914	-----	11.000	3.600	3.600	120.000	125.000	95.72
860909	914	860916	912	5.314	7.300	3.800	3.700	82.000	86.000	98.40
860916	912	860923	949	-----	8.000	3.600	3.700	104.000	109.000	99.26
860923	949	860930	921	2.923	4.100	3.900	3.900	50.000	49.000	98.40
860930	921	861007	915	3.410	3.400	4.000	4.000	49.000	49.000	92.94
861007	915	861014	918	.974	1.400	4.400	4.400	19.000	19.000	81.38
861014	918	861021	911							
861021	911	861028	620	1.993	2.000	4.300	4.200	25.000	32.000	193.56
861028	620	861104	620							
861104	620	861111	838	1.151	1.400	4.500	4.300	17.000	22.000	93.56
861111	838	861118	918	.576	.700	4.700	4.400	12.000	14.000	102.09

Table B-8.-- Chemical data for Duplicate Samples from Sampler A-2

[Units for concentration for all ionic analytes, milligrams per liter; conduct, specific conductance, microsiemens per centimeter; pH, pH units; Field, determined at U.S. Military Academy; Lab, determined at U.S. Geological Survey; Collect Effic, Collection Efficiency, percent indicates missing data.]

Date On	Time On	Date Off	Time Off	Sample Weight	[Ca ⁺⁺]	[Mg ⁺⁺]	[Na ⁺]	[K ⁺]	[NH ₄ ⁺]	[Cl ⁻]
860114	900	860121	909	867.2	0.010	0.020	0.440	0.020	0.061	1.300
860121	909	860128	938	5882.2	.000	.000	.250	.030	.049	.450
860128	938	860204	905	755.9	.000	.000	.380	.060	.376	.560
860204	905	860211	934	1253.6	.100	.030	.450	.010	.061	.260
860211	934	860218	910	1246.1	.100	.040	.240	.030	.243	.390
860218	910	860225	849	3340.5	.080	.030	.080	.010	.134	.250
860225	849	860304	719	0						
860304	719	860311	831	273.1	.580	.130	.630	.120	1.214	1.100
860311	831	860318	822	3313.6	.020	.030	.190	.040	.134	.360
860318	822	860325	838	254.6	.700	.190	-----	.110	.886	1.300
860325	838	860401	923	138.3	.570	.160	.220	.060	.716	.510
860401	923	860408	849	865.8	.290	.110	.430	.040	.571	1.100
860408	849	860415	853	0						
860415	853	860422	847	4087.6	.020	.030	.370	.020	.401	.320
860422	847	860429	900	1965.7	.100	.060	.110	.030	.510	.260
860429	900	860506	853	694.8	.360	.070	.100	.060	.862	.360
860506	852	860513	846	481.4	.430	.060	.100	.080	.777	.380
860513	846	860520	853	0						
860520	853	860527	905	2121.3	.040	.060	.410	.050	.170	-----
860527	830	860603	853	389.5	.930	.190	.030	.160	1.154	-----
860603	853	860610	912	5796.7	.170	.050	.120	.010	.267	.210
860610	912	860617	914	2952.1	.070	.030	.050	.010	.182	.130
860617	914	860624	932	256.3	.290	.040	.020	.030	.607	.270
860624	932	860701	925	1032.4	.010	.050	.050	.060	.729	.300
860701	925	860708	925	2684.7	.010	.020	.070	.010	.085	.170
860708	925	860715	923	3320.8	.020	.030	.050	.120	.206	.240
860715	923	860722	910	0						
860722	910	860729	908	3839.3	.040	.030	.050	.040	.219	.190
860729	908	860805	912	3886.8	.070	.030	.050	.030	.389	.270
860805	912	860812	850	164.5						
860812	850	860819	929	679.9	.020	.040	.010	.110	.146	.200
860819	929	860826	916	1531.5	.010	.020	.010	.120	.049	.120
860826	916	860902	934	208.8	-----	-----	-----	-----	-----	-----
860902	934	860909	916	762.7	.050	.030	.090	.130	.704	.400
860909	916	860916	918	259.5	.160	.030	.050	.030	.874	.230
860916	918	860923	942	652.2	.170	.050	.150	.010	1.044	.400
860923	942	860930	925	593.5	.140	.040	.070	.010	.316	.240
860930	925	861007	921	1716.1	.100	.030	.140	.010	.279	.230
861007	921	861014	920	733.2	.070	.020	.100	.010	.085	.120
861014	920	861021	913	0						
861021	913	861028	703	1040.5	.050	.030	.090	.010	.182	.250
861028	703	861104	610	0						
861104	610	861111	833	2554.1	.040	.030	.090	.010	.073	.500
861111	833	861118	912	1275.7	.040	.010	.070	.010	.061	.410
861118	912	861125	916	5452.8	.040	.030	.110	-----	.097	.210
861125	916	861202	904	1675.9	.010	.000	.080	-----	.049	.150
861202	904	861209	1025	3356.5	.020	.040	.360	.010	.049	.610

Table B-8.-- Chemical data for duplicate samples from Sampler A-2 (continued)

Date On	Time On	Date Off	Time Off	[NO ₃ ⁻]	[SO ₄ ⁼]	Lab pH	Field pH	Lab Conduct	Field Conduct	Collect Effic
860114	900	860121	909	1.329	1.300	4.100	4.100	36.000	35.000	89.81
860121	909	860128	938	.487	.900	4.600	4.500	15.000	13.000	99.46
860128	938	860204	905	4.871	3.000	4.000	4.000	54.000	54.000	101.95
860204	905	860211	934	1.904	1.100	4.300	4.300	24.000	25.000	60.59
860211	934	860218	910	2.569	2.900	4.000	4.000	43.000	39.000	100.38
860218	910	860225	849	1.417	2.300	4.200	4.200	33.000	30.000	150.19
860225	849	860304	719							
860304	719	860311	831	5.757	5.800	3.900	3.900	74.000	70.000	98.99
860311	831	860318	822	1.151	2.000	4.300	4.300	25.000	27.000	86.97
860318	822	860325	838	3.853	4.900	4.200	4.200	48.000	47.000	92.29
860325	838	860401	923	2.214	3.000	4.000	3.900	72.000	58.000	114.59
860401	923	860408	849	5.757	5.600	3.800	3.800	79.000	84.000	96.57
860408	849	860415	853							
860415	853	860422	847	1.461	3.800	4.100	4.100	39.000	41.000	100.03
860422	847	860429	900	3.100	4.100	4.100	4.000	47.000	47.000	97.44
860429	900	860506	853	5.757	6.300	3.800	3.800	81.000	85.000	103.32
860506	852	860513	846	4.871	7.300	3.800	3.800	88.000	85.000	93.07
860513	846	860520	853							
860520	853	860527	905	1.373	1.700	4.400	4.500	23.000	23.000	100.02
860527	830	860603	853	4.163	7.300	4.000	4.000	64.000	57.000	94.12
860603	853	860610	912	2.613	3.300	4.100	4.100	40.000	74.000	96.05
860610	912	860617	914	1.506	2.400	4.200	4.200	29.000	38.000	100.12
860617	914	860624	932	5.757	5.200	3.800	3.800	74.000	74.000	78.23
860624	932	860701	925	4.871	7.900	3.700	-----	90.000	92.000	99.79
860701	925	860708	925	.886	1.100	4.500	4.500	16.000	17.000	97.93
860708	925	860715	923	2.303	3.800	4.000	4.000	47.000	44.000	95.34
860715	923	860722	910							
860722	910	860729	908	2.037	2.600	4.200	4.100	36.000	37.000	94.75
860729	908	860805	912	3.941	5.700	3.800	3.800	74.000	78.000	100.64
860805	912	860812	850							86.73
860812	850	860819	929	1.771	2.200	4.200	4.100	30.000	32.000	96.18
860819	929	860826	916	1.107	1.300	4.400	4.300	20.000	20.000	98.69
860826	916	860902	934	-----	-----	-----	-----	-----	-----	93.15
860902	934	860909	916	-----	5.100	3.600	3.600	115.000	116.000	98.30
860909	916	860916	918	4.871	6.900	3.700	3.700	77.000	88.000	100.34
860916	918	860923	942	-----	7.400	3.600	3.700	101.000	103.000	94.56
860923	942	860930	925	2.746	3.900	4.000	4.000	47.000	48.000	95.61
860930	925	861007	921	3.366	3.400	4.000	4.000	49.000	49.000	91.31
861007	921	861014	920	.886	1.200	4.400	4.400	17.000	18.000	72.07
861014	920	861021	913							
861021	913	861028	703	1.683	1.700	4.400	4.200	22.000	29.000	90.07
861028	703	861104	610							
861104	610	861111	833	1.063	1.300	4.400	4.300	20.000	25.000	93.16
861111	833	861118	912	.531	.700	4.700	4.500	12.000	13.000	102.76
861118	912	861125	916	1.107	.700	4.700	4.500	12.000	14.000	103.35
861125	916	861202	904	.177	.400	5.400	4.800	4.000	6.000	100.20
861202	904	861209	1025	.576	.750	5.100	4.600	9.000	13.000	101.92

Table B-9.-- Summary of amounts of precipitation collected by each rain gage during the period 14 January 1986 to 30 December 1986 [Amounts are given in equivalent millimeters of water.]

Date on	Date off	NADP	RG-1	RG-2	RG-6	NWS8
Jan 14	Jan 21	14.2	14.5	15.0	12.2	13.5
Jan 21	Jan 28	87.1	87.9	87.4	93.2	93.2
Jan 28	Feb 4	10.9	11.9	12.7	13.2	15.5
Feb 4	Feb 11	30.5	32.5	30.5	35.8	33.0
Feb 11	Feb 18	18.3	18.5	19.6	21.8	19.8
Feb 18	Feb 25	32.8	29.2	32.3	31.2	34.0
Feb 25	Mar 4	0.0	0.0	0.0	0.0	0.0
Mar 4	Mar 11	4.1	3.0	4.6	4.3	3.3
Mar 11	Mar 18	54.9	55.9	55.9	55.4	56.9
Mar 18	Mar 25	4.1	3.3	4.6	9.1	2.5
Mar 25	Apr 1	1.8	1.8	2.0	1.8	1.0
Apr 1	Apr 8	13.2	14.2	16.5	15.7	15.5
Apr 8	Apr 15	0.0	0.0	0.0	0.0	0.0
Apr 15	Apr 22	60.2	59.9	61.0	72.4	64.3
Apr 22	Apr 29	29.7	30.2	24.9	34.5	33.5
Apr 29	May 6	9.9	10.2	10.2	17.0	10.4
May 6	May 13	7.6	6.9	7.9	6.4	6.4
May 13	May 20	0.3	0.0	0.3	0.0	0.3
May 20	May 27	31.2	32.3	32.5	30.2	32.3
May 27	Jun 3	6.1	6.1	5.6	5.8	0.5
Jun 3	Jun 10	88.9	87.1	88.4	75.7	90.4
Jun 10	Jun 17	43.4	41.7	44.2	39.1	45.2
Jun 17	Jun 24	4.8	4.3	3.8	10.2	4.6
Jun 24	Jul 1	15.2	15.2	15.2	21.8	16.3
Jul 1	Jul 8	40.4	39.9	40.4	37.8	43.9
Jul 8	Jul 15	51.3	49.8	51.6	51.8	53.1
Jul 15	Jul 22	1.0	0.8	1.0	1.0	0.8
Jul 22	Jul 29	59.7	55.4	58.2	53.1	58.7
Jul 29	Aug 5	56.9	55.9	57.7	44.2	59.4
Aug 5	Aug 12	2.8	2.0	2.0	2.0	2.8
Aug 12	Aug 19	10.4	9.4	10.4	9.7	11.4
Aug 19	Aug 26	22.9	22.1	24.4	22.4	23.6
Aug 26	Sep 2	3.3	2.3	3.3	2.5	3.3
Sep 2	Sep 9	11.4	11.2	11.4	14.5	11.7
Sep 9	Sep 16	3.8	3.6	3.6	5.6	3.6
Sep 16	Sep 25	10.2	9.7	9.9	8.9	10.9
Sep 23	Sep 30	9.1	7.4	8.4	11.4	10.2
Sep 30	Oct 7	27.7	25.7	25.4	27.9	24.6
Oct 7	Oct 14	15.0	12.2	13.7	11.9	12.7
Oct 14	Oct 21	0.0	0.0	0.0	0.0	0.0
Oct 21	Oct 28	17.0	16.3	17.8	16.5	17.3
Oct 28	Nov 4	0.5	0.5	0.5	1.0	1.0
Nov 4	Nov 11	40.4	40.4	41.1	42.4	40.6
Nov 11	Nov 18	18.3	18.3	17.8	15.2	19.3
Nov 18	Nov 25	77.7	78.2	79.0	87.4	77.2
Nov 25	Dec 2	24.6	25.4	25.4	25.9	24.4
Dec 2	Dec 9	48.3	51.8	50.8	51.1	50.3
Dec 9	Dec 16	13.5	13.0	13.5	13.2	13.5
Dec 16	Dec 23	43.2	41.4	43.9	41.4	42.4
Dec 23	Dec 30	34.5	34.5	35.6	32.3	35.1

APPENDIX C: (1) Percentile Summaries of Concentrations of Selected Analytes, to Include Sample Weight for Samplers A-1 to A-3, G-4, A-5 to A-6 and V-7. (Tables C-1 to C-13)

(2) Relation between the collection week and sampling period. (Table C-14)

(3) Differences in volume-weighted-average concentrations of selected analytes between samplers. (Table C-15 to C-24)

Table C-1.-- *Percentile Summary of Sample Weight Data* [units, grams]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	44	205.4	596.8	1037.6	2590.4	4025.4
A-2	44	254.6	652.2	1246.1	2721.2	4087.6
A-3	44	267.3	596.2	1187.9	2631.2	4121.3
G-4	41	130.9	300.1	637.6	1343.8	3021.7
A-5	44	212.7	623.4	1032.5	2662.4	4169.9
A-6	44	293.9	672.4	1428.9	2522.2	4322.3
V-7	38	199.9	510.0	1050.1	2236.0	3804.7

Table C-2.-- *Percentile Summary of Calcium Data* [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	0.010	0.020	0.080	0.220	0.380
A-2	44	.010	.020	.070	.160	.570
A-3	43	.010	.020	.070	.170	.650
G-4	40	.010	.010	.080	.140	.460
A-5	43	.010	.020	.070	.170	.430
A-6	43	.010	.020	.080	.180	.430
V-7	37	.010	.050	.100	.200	.430

Table C-3.-- *Percentile Summary of Magnesium Data* [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	0.020	0.030	0.040	0.050	0.110
A-2	44	.020	.030	.030	.050	.130
A-3	42	.010	.030	.040	.050	.120
G-4	40	.010	.020	.030	.050	.110
A-5	42	.020	.030	.030	.050	.110
A-6	43	.020	.020	.030	.040	.120
V-7	37	.020	.030	.040	.060	.110

Table C-4.-- *Percentile Summary of Sodium Data* [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	0.010	0.060	0.120	0.230	0.400
A-2	44	.010	.060	.110	.220	.420
A-3	43	.010	.060	.110	.230	.450
G-4	40	.010	.060	.100	.240	.390
A-5	42	.010	.060	.110	.220	.430
A-6	43	.030	.070	.090	.290	.460
V-7	37	.030	.070	.130	.240	.490

Table C-5.-- Percentile Summary of Potassium Data [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	40	0.010	0.010	0.020	0.050	0.100
A-2	42	.010	.010	.020	.060	.110
A-3	38	.010	.010	.030	.090	.110
G-4	38	.010	.010	.020	.050	.100
A-5	40	.010	.010	.020	.070	.160
A-6	40	.010	.010	.020	.080	.100
V-7	37	.010	.020	.030	.090	.160

Table C-6.-- Percentile Summary of Ammonium Data [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	0.061	0.097	0.231	0.656	0.911
A-2	44	.049	.085	.219	.595	.899
A-3	43	.049	.085	.255	.704	1.081
G-4	40	.061	.073	.206	.668	.886
A-5	42	.061	.085	.231	.571	.874
A-6	43	.049	.085	.219	.546	.838
V-7	37	.073	.134	.304	.692	1.093

Table C-7.-- Percentile Summary of Chloride Data [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	42	0.130	0.210	0.270	0.520	0.940
A-2	41	.150	.210	.270	.460	.920
A-3	40	.170	.230	.330	.420	.950
G-4	37	.150	.190	.290	.470	.850
A-5	39	.160	.220	.320	.440	.900
A-6	41	.150	.210	.280	.460	.680
V-7	36	.170	.230	.310	.400	.760

Table C-8.-- Percentile Summary of Nitrate Data [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	40	0.576	1.019	2.037	3.897	4.871
A-2	41	.576	1.151	1.904	4.119	5.757
A-3	40	.576	1.151	1.949	4.074	5.757
G-4	39	.487	.886	1.639	3.189	4.871
A-5	39	.576	1.107	1.993	3.986	4.871
A-6	41	.576	1.107	2.170	3.853	4.871
V-7	34	.930	1.461	2.303	4.871	5.757

Table C-9.-- Percentile Summary of Sulfate Data [units, mg/liter]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	0.800	1.200	2.700	5.200	7.400
A-2	44	.700	1.200	2.600	5.300	7.400
A-3	43	.700	1.200	2.800	5.700	7.800
G-4	40	.800	1.200	2.500	5.100	7.300
A-5	43	.700	1.300	2.800	5.500	7.900
A-6	43	.800	1.200	2.900	5.600	7.700
V-7	37	1.200	2.000	3.400	5.800	7.600

Table C-10.-- Percentile Summary of U.S. Geological Survey determined pH Data [units, pH Units]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	42	3.700	3.900	4.100	4.400	4.800
A-2	44	3.800	3.900	4.100	4.400	5.700
A-3	42	3.700	3.800	4.100	4.500	4.800
G-4	40	3.700	3.900	4.200	4.400	4.600
A-5	43	3.700	3.800	4.100	4.400	4.800
A-6	42	3.700	3.900	4.100	4.500	4.800
V-7	37	3.700	3.800	4.000	4.300	4.400

Table C-11.-- Percentile Summary of U.S. Military Academy determined pH Data [units, pH Units]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	3.700	3.900	4.100	4.300	4.600
A-2	44	3.700	3.900	4.100	4.300	4.500
A-3	42	3.700	3.900	4.100	4.300	4.600
G-4	40	3.700	3.800	4.100	4.300	4.400
A-5	42	3.700	3.800	4.100	4.300	4.500
A-6	42	3.700	3.900	4.100	4.300	4.500
V-7	37	3.700	3.800	4.000	4.200	4.400

Table C-12.-- Percentile Summary of U.S. Geological Survey Determined Specific Conductance Values by Percentiles [units, $\mu\text{S}/\text{cm}$]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	13.000	20.000	39.000	62.000	89.000
A-2	44	10.000	19.000	39.000	62.000	83.000
A-3	43	12.000	21.000	43.000	75.000	90.000
G-4	40	12.000	18.000	32.000	62.000	83.000
A-5	43	10.000	19.000	40.000	63.000	92.000
A-6	43	10.000	18.000	38.000	66.000	84.000
V-7	37	17.000	25.000	42.000	75.000	93.000

Table C-13.-- Percentile Summary of U.S. Military Academy Determined Specific Conductance Values by Percentiles [units, $\mu\text{S}/\text{cm}$]

Sampler	Number of Samples	Percentiles				
		10	25	50	75	90
A-1	43	13.000	21.000	38.000	62.000	88.000
A-2	44	13.000	23.000	39.000	70.000	88.000
A-3	43	13.000	21.000	37.000	68.000	90.000
G-4	40	13.000	19.000	36.000	61.000	80.000
A-5	43	13.000	20.000	38.000	63.000	88.000
A-6	43	12.000	20.000	41.000	62.000	90.000
V-7	37	19.000	26.000	44.000	80.000	91.000

Table C-14.-- Relation between collection week and sampling period [860114, January 14, 1986]

Collection Week	Date On	Date Off	Collection Week	Date On	Date Off
1	860114	860121	26	860708	860715
2	860121	860128	27	860715	860722
3	860128	860204	28	860722	860729
4	860204	860211	29	860729	860805
5	860211	860218	30	860805	860812
6	860218	860225	31	860812	860819
7	860225	860304	32	860819	860826
8	860304	860311	33	860826	860902
9	860311	860318	34	860902	860909
10	860318	860325	35	860909	860916
11	860325	860401	36	860916	860923
12	860401	860408	37	860923	860930
13	860408	860415	38	860930	861007
14	860415	860422	39	861007	861014
15	860422	860429	40	861014	861021
16	860429	860506	41	861021	861028
17	860506	860513	42	861028	861104
18	860513	860520	43	861104	861111
19	860520	860527	44	861111	861118
20	860527	860603	45	861118	861125
21	860603	860610	46	861125	861202
22	860610	860617	47	861202	861209
23	860617	860624	48	861209	861216
24	860624	860701	49	861216	861223
25	860701	860708	50	861223	861230

Table C-15.-- Difference in the volume weighted concentrations of Calcium [* Denotes a difference greater than or equal to the difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	-0.001						
A-3	0.004	0.005					
G-4	0.011	0.012	0.007				
A-5	-0.015*	-0.014	-0.019*	-0.026*			
A-6	0.002	0.003	-0.002	-0.009	0.017*		
V-7	-0.043*	-0.042*	-0.047*	-0.054*	-0.028*	-0.045*	
A-2 DUP	0.014	0.015	0.010	0.003	0.029*	0.012	0.057*

Table C-16.-- *Difference in the volume weighted concentrations of Magnesium*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	0						
A-3	-0.002	-0.002					
G-4	0.004*	0.004*	0.006*				
A-5	-0.007*	-0.007*	-0.005*	-0.011*			
A-6	0.004*	0.004*	0.006*	0	0.011*		
V-7	-0.007*	-0.007*	-0.005*	-0.011*	0	-0.011*	
A-2 DUP	0.003*	0.003*	0.005*	-0.001	0.010*	-0.001	0.01

Table C-17.-- *Difference in the volume weighted concentrations of Potassium*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	0						
A-3	-0.016*	-0.016*					
G-4	0.003	0.003	0.019*				
A-5	-0.007*	-0.007*	0.009*	-0.010*			
A-6	0	0	0.016*	-0.003	0.007*		
V-7	-0.035*	-0.035*	-0.019*	-0.038*	-0.028*	-0.035*	
A-2 DUP	-0.005*	-0.005*	0.011*	-0.008*	0.002	-0.005*	0.030*

Table C-18.-- *Difference in the volume weighted concentrations of Ammonium*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	0.002*						
A-3	-0.055*	-0.057*					
G-4	0.010*	0.008*	0.065*				
A-5	-0.002*	-0.004*	0.053*	-0.012*			
A-6	0.011*	0.009*	0.066*	0.001	0.013*		
V-7	-0.137*	-0.139*	-0.082*	-0.147*	-0.135*	-0.148*	
A-2 DUP	0.003*	0.001*	0.058*	-0.007*	0.005*	-0.008*	0.140*

Table C-19.-- *Difference in the volume weighted concentrations of Chloride*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	-0.019*						
A-3	-0.028*	-0.009*					
G-4	0.002*	0.021*	0.030*				
A-5	-0.006*	0.013*	0.022*	-0.008*			
A-6	0.007*	0.026*	0.035*	0.005*	0.013*		
V-7	-0.025*	-0.006*	0.003*	-0.027*	-0.019*	-0.032*	
A-2 DUP	-0.018*	0.001	0.010*	-0.020*	-0.012*	-0.025*	0.007*

Table C-20.-- *Difference in the volume weighted concentrations of Sodium*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	0.004						
A-3	0.009*	0.005					
G-4	0.014*	0.010*	0.005				
A-5	0.024*	0.020*	0.015*	0.010*			
A-6	0	-0.004	-0.009*	-0.014*	-0.024*		
V-7	-0.014*	-0.018*	-0.023*	-0.028*	-0.038*	-0.014*	
A-2 DUP	-0.002	-0.006	-0.011*	-0.016*	-0.026*	-0.002	0.012*

Table C-21.-- *Difference in the volume weighted concentrations of Nitrate*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	-0.039*						
A-3	-0.113*	-0.074*					
G-4	0.230*	0.269*	0.343*				
A-5	-0.021*	0.018*	0.092*	-0.251*			
A-6	0.009*	0.048*	0.122*	-0.221*	0.030*		
V-7	-0.179*	-0.140*	-0.066*	-0.409*	-0.158*	-0.188*	
A-2 DUP	-0.046*	-0.007*	0.067*	-0.276*	-0.025*	-0.055*	0.133*

Table C-22.-- *Difference in the volume weighted concentrations of Sulfate*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	-0.02						
A-3	-0.15*	-0.13*					
G-4	0.22*	0.24*	0.37*				
A-5	-0.03	-0.01	0.12*	-0.25*			
A-6	0.19*	0.21*	0.34*	-0.03	0.22*		
V-7	-0.22*	-0.20*	-0.07	-0.44*	-0.19*	-0.41*	
A-2 DUP	0.05	0.07	0.20*	-0.17*	0.08*	-0.14*	0.27*

Table C-23.-- *Difference in the volume weighted concentrations of Field Hydrogen Ion*
 [* Denotes a difference greater than or equal to the
 difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	0.4*						
A-3	1.3*	0.9*					
G-4	1.2*	0.8*	-0.1*				
A-5	1.0*	0.6*	-0.3*	-0.2*			
A-6	0.9*	0.5*	-0.4*	-0.3*	-0.1*		
V-7	0.4*	0	-0.9*	-0.8*	-0.6*	-0.5*	
A-2 DUP	0.4*	0	-0.9*	-0.8*	-0.6*	-0.5*	0

Table C-24.-- *Difference in the volume weighted concentrations of Lab Hydrogen Ion* [* Denotes a difference greater than or equal to the difference between A-2 and the duplicate analysis of A-2.]

	A-1	A-2	A-3	G-4	A-5	A-6	V-7
A-2	-0.1						
A-3	-0.1	0					
G-4	1	1.1*	1.1*				
A-5	0.1	0.2*	0.2*	-0.9*			
A-6	0.7*	0.8*	0.8*	-0.3*	0.6*		
V-7	-0.1	0	0	-1.1*	-0.2*	-0.8*	
A-2 DUP	0	0.1	0.1	-1.0*	-0.1	-0.7*	0.1

APPENDIX D: Graphs of normalized residuals as a function of predicted concentrations of analytes; shows the constancy of variance of residuals for samplers A-1 to A-6; January 1986 to December 1986.

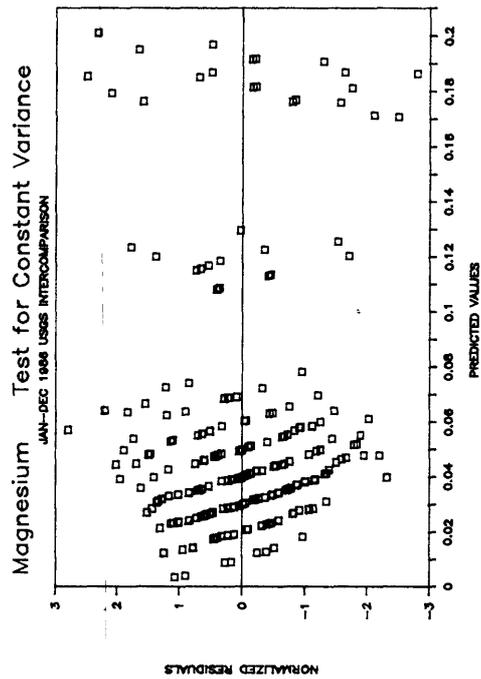
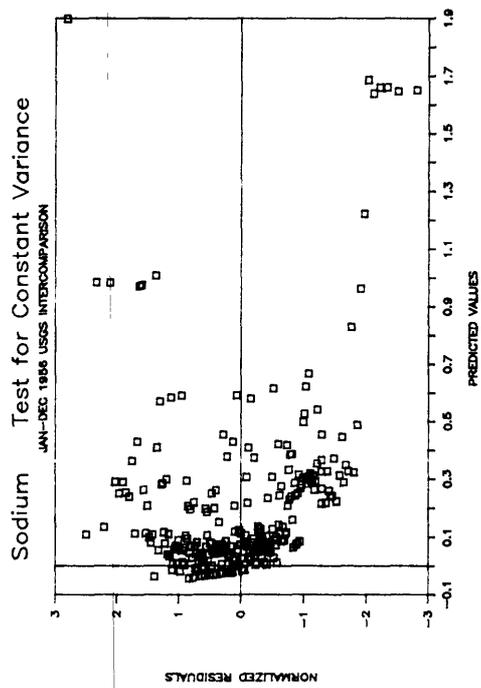
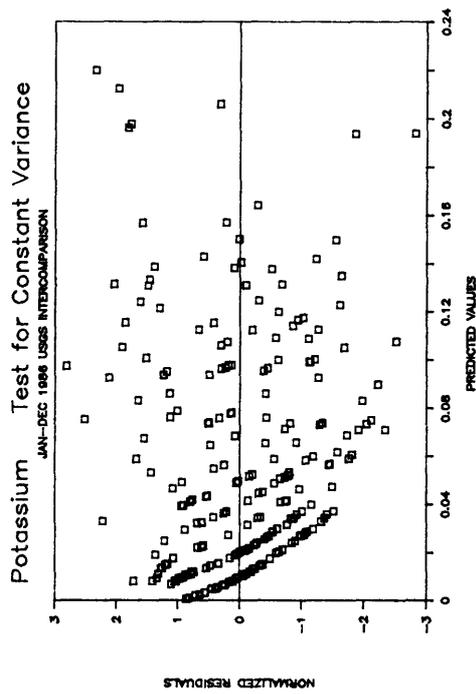
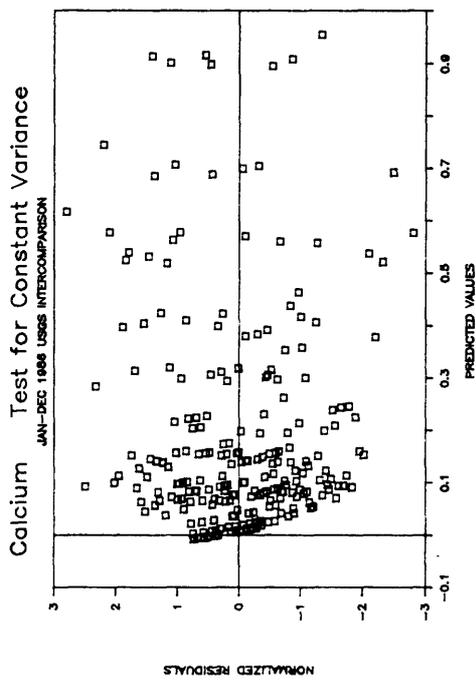


Figure D-1.--- Normalized residuals as a function of predicted concentration of calcium, magnesium, sodium and potassium; January to December 1986.

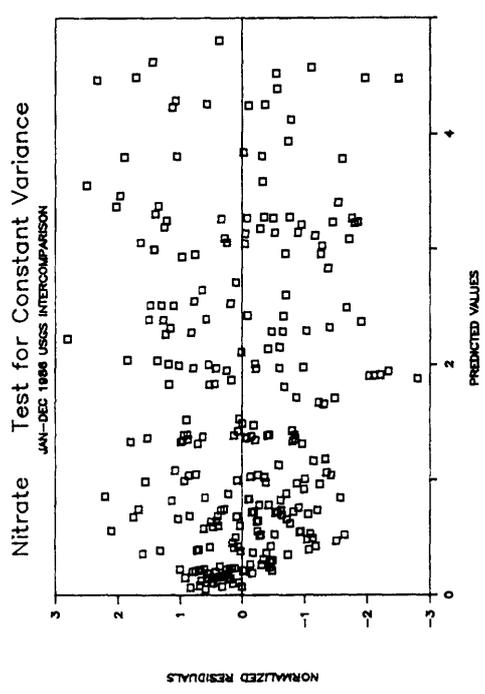
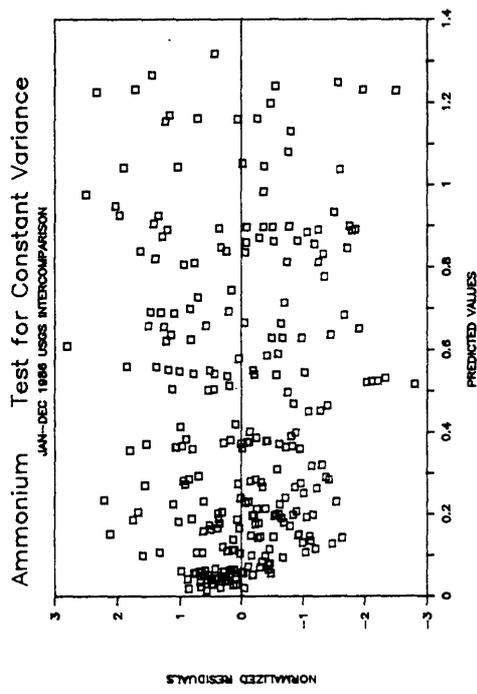
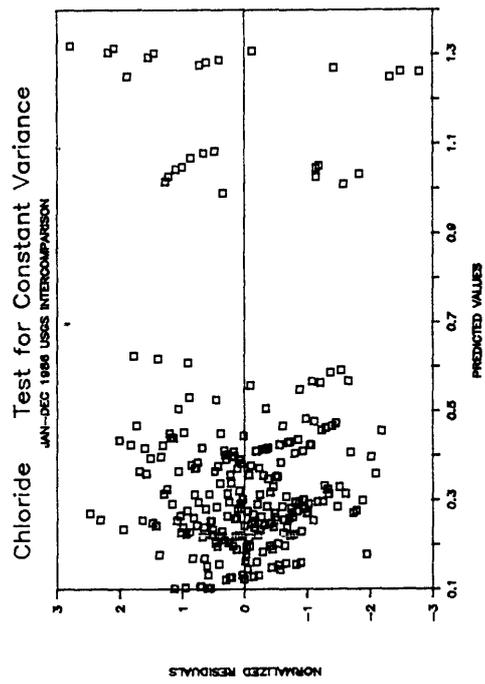
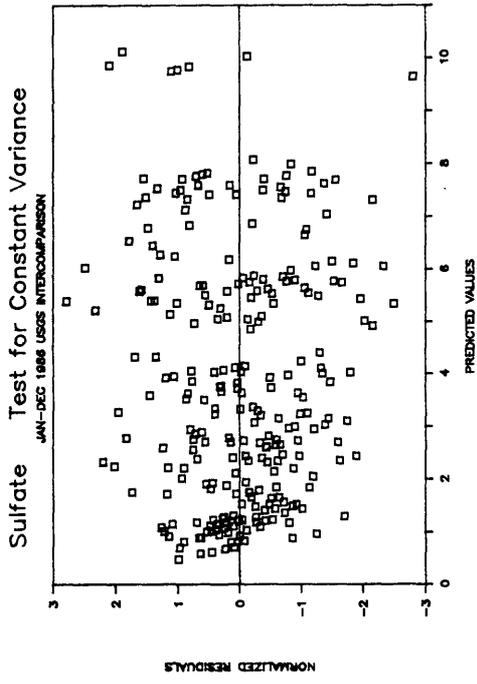


Figure D-2.-- Normalized residuals as a function of predicted concentration of ammonium, sulfate, nitrate and chloride; January to December 1986.

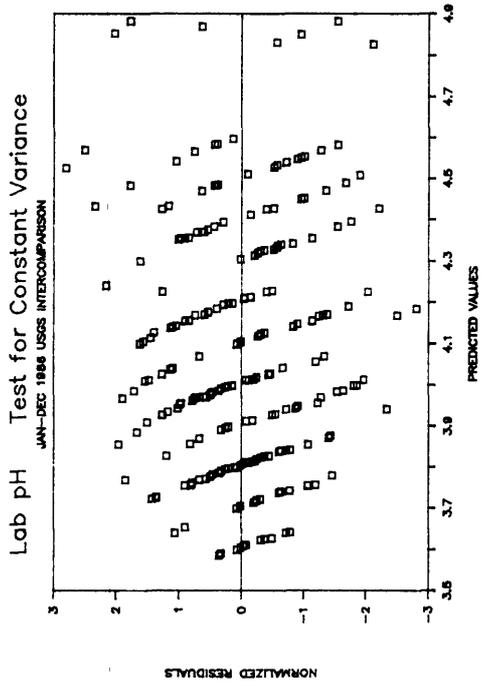
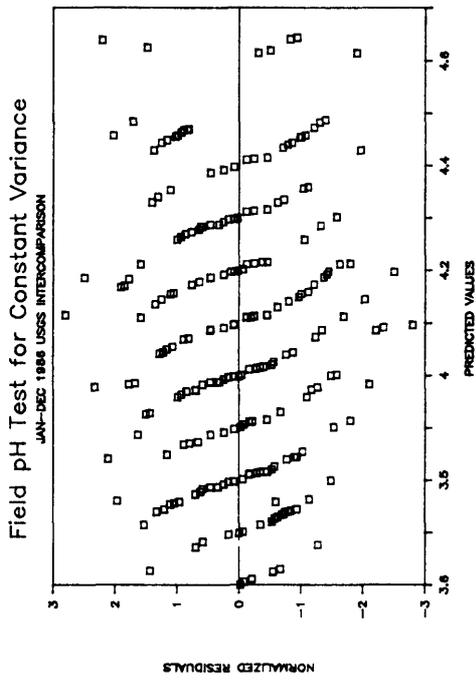
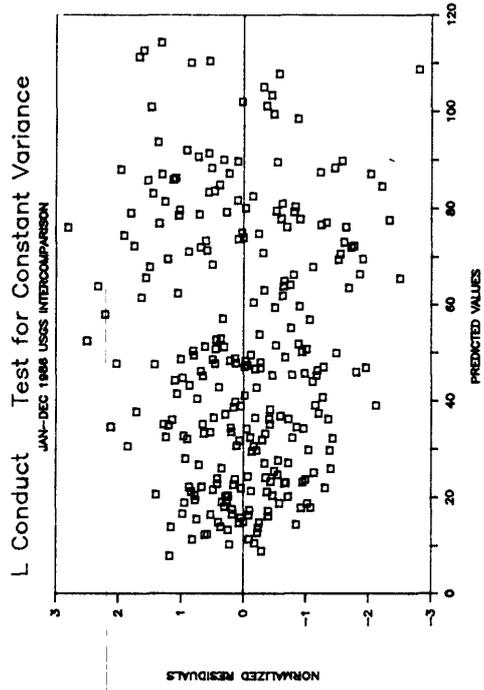
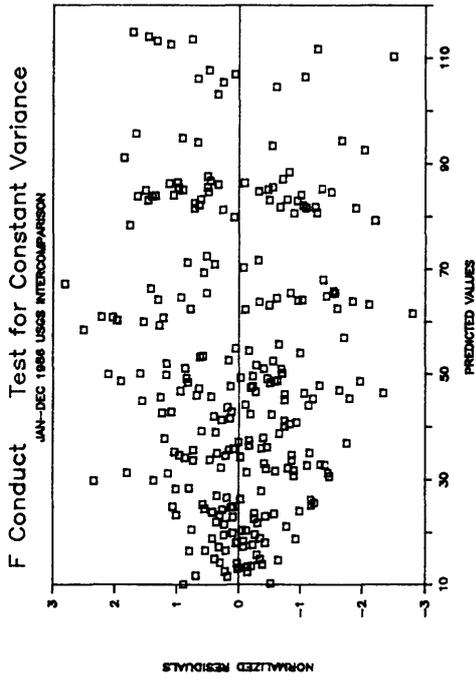


Figure D-3.-- Normalized residuals as a function of predicted values of field pH, field conductance, laboratory pH, and laboratory conductance; January to December 1986.

APPENDIX E: Graphs of residuals as a function of normalized residuals; shows the constancy of variance of residuals for samplers A-1 to A-6; January 1986 to December 1986.

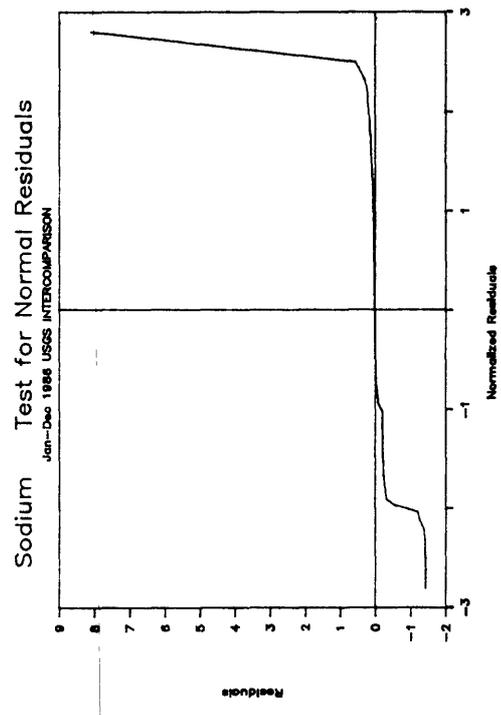
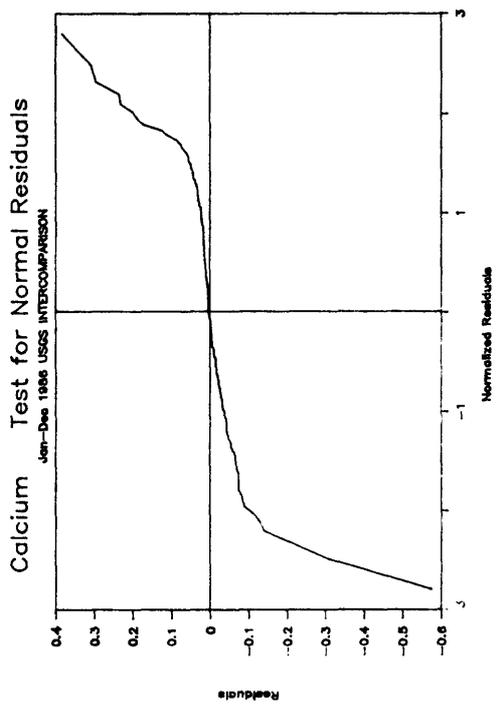
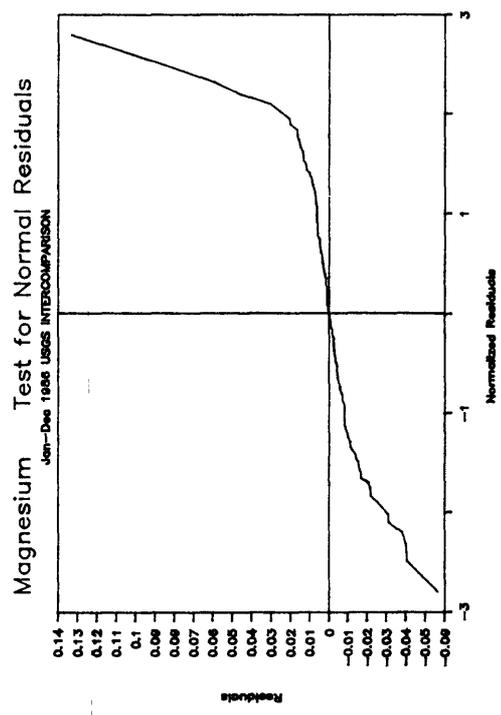
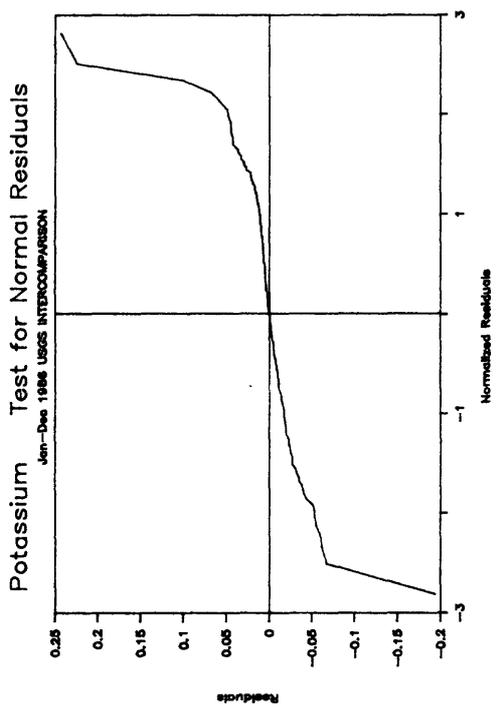


Figure E-1.-- Residuals as a function of normalized residuals; January to December 1986; calcium, magnesium, sodium and potassium.

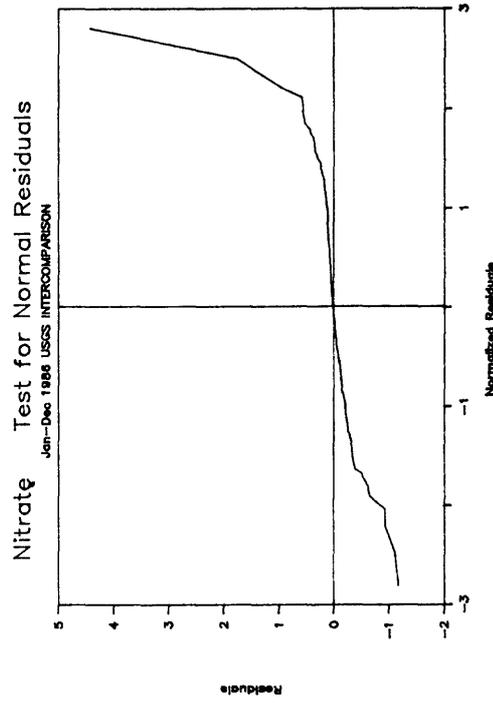
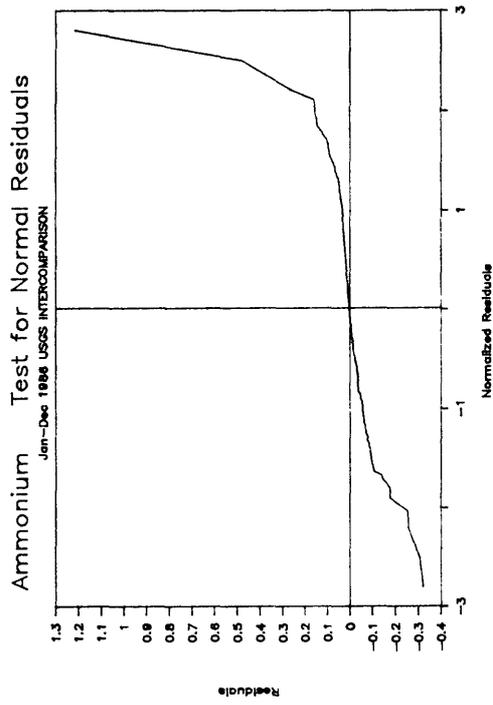
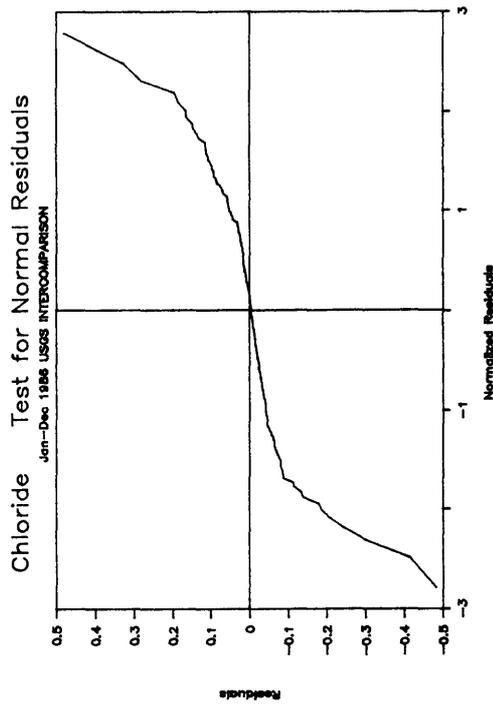
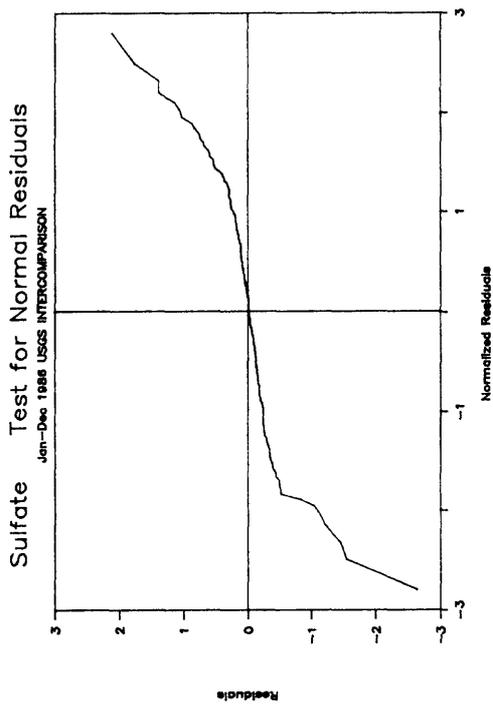


Figure E-2.-- Residuals as a function of normalized residuals; January to December 1986; ammonium, sulfate, nitrate and chloride.

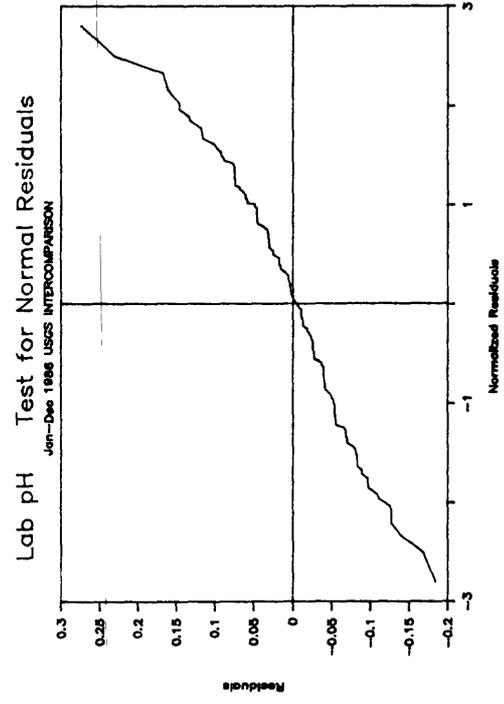
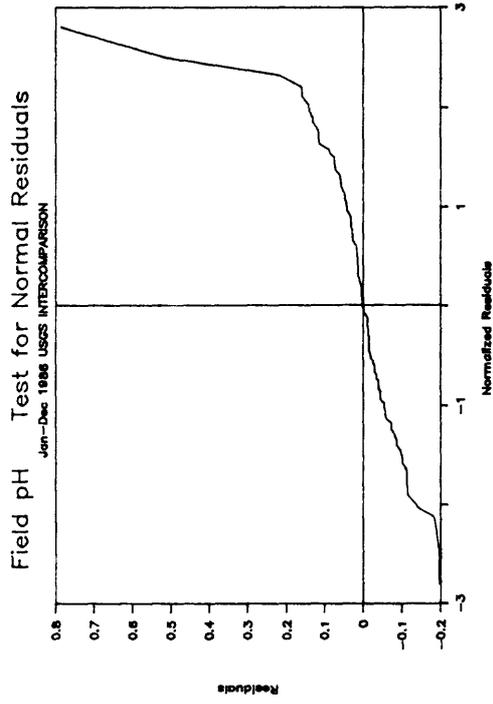
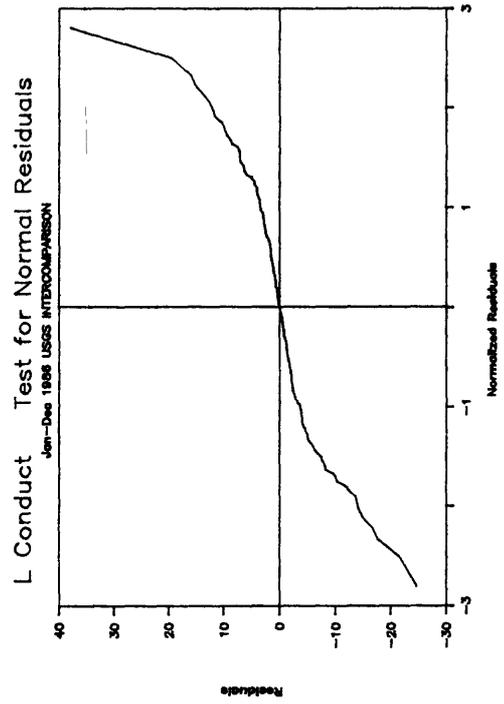
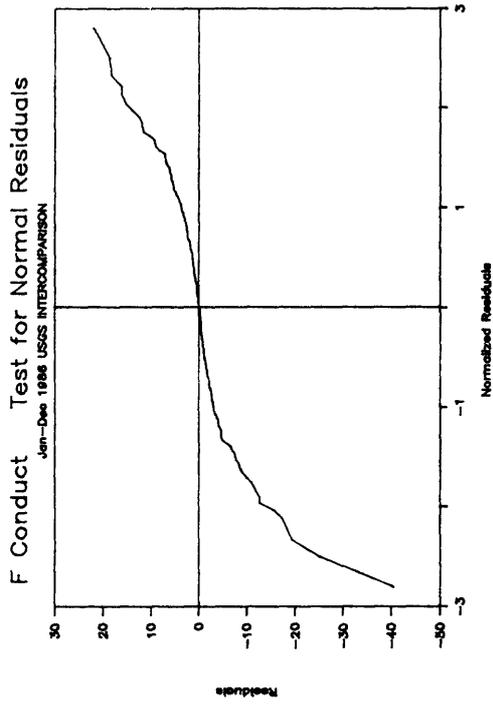


Figure E-3.-- Residuals as a function of normalized residuals; January to December 1986; field pH, field conductance, laboratory pH, laboratory conductance.

APPENDIX F: Pairwise differences of sum of ranks from Friedman test for detecting differences in the performance of samplers; concentration of analytes used in the statistical analysis, January 1986 to December 1986

Table F-1.-- Summary of sum of rank differences indicated by Friedman test for calcium concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 37; number of columns= 7. T2= 4.526; F-value ($\alpha= 0.01$) 3.362; F-value ($\alpha= 0.05$) 2.372. Significant difference value= 30.96. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	11.50	35.50*	4.00	21.00	2.50	59.50*
A-2		24.00	15.50	9.50	9.00	48.00*
A-3			39.50*	14.50	33.00*	24.00
G-4				25.00	6.50	63.50*
A-5					18.50	38.50*
A-6						57.00*

Table F-2.-- Summary of sum of rank differences indicated by Friedman test for chloride concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 36; number of columns= 7. T2= 5.155; F-value ($\alpha= 0.01$) 3.380; F-value ($\alpha= 0.05$) 2.380. Significant difference value= 31.05. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	13.00	47.50*	9.00	31.50	17.50	43.00*
A-2		34.50*	22.00	18.50	30.50	30.00
A-3			56.50*	16.00	65.00*	4.50
G-4				40.50*	8.50	52.00*
A-5					49.00*	11.50
A-6						60.50*

Table F-3.-- Summary of sum of rank differences indicated by Friedman test for conductance [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 5.267; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 35.315. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	25.50	51.00*	9.00	36.00*	2.00	63.00*
A-2		25.50	34.50	10.50	27.50	37.50*
A-3			60.00*	15.00	53.00*	12.00
G-4				45.00*	7.00	72.00*
A-5					38.00*	27.00
A-6						65.00*

Table F-4.-- Summary of sum of rank differences indicated by Friedman test for pH [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 2.503; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 26.91. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	3.00	4.00	26.50	8.00	24.50	14.50
A-2		7.00	29.50*	11.00	27.50*	11.50
A-3			22.50	4.00	20.50	18.50
G-4				18.50	2.00	41.00*
A-5					16.50	22.50
A-6						39.00*

Table F-5.-- Summary of sum of rank differences indicated by Friedman test for potassium concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 6.584; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 31.05. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	4.00	43.50*	11.00	27.50	9.50	73.50*
A-2		47.50*	15.00	31.50*	13.50	77.50*
A-3			32.50*	16.00	34.00*	30.00
G-4				16.50	1.50	62.50*
A-5					18.00	46.00*
A-6						64.00*

Table F-6.-- Summary of sum of rank differences indicated by Friedman test for conductance [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 39; number of columns= 7. T2= 6.386; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 35.60. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	13.50	53.00*	14.00	39.00*	0.00	69.50*
A-2		39.50*	27.50	25.50	13.50	56.00*
A-3			67.00*	14.00	53.00*	16.50
G-4				53.00*	14.00	83.50*
A-5					39.00*	30.50
A-6						69.50*

Table F-7.-- Summary of sum of rank differences indicated by Friedman test for pH concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns=7. T2= 4.568; F-value ($\alpha=0.01$) 3.344; F-value ($\alpha= 0.05$) 2.311. Significant difference value= 29.27. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	6.00	31.00*	25.00	9.50	19.50	29.50*
A-2		25.00	31.00*	3.50	25.50	23.50
A-3			56.00*	21.50	50.50*	1.50
G-4				34.50*	5.50	54.50*
A-5					29.00	20.00
A-6						49.00*

Table F-8.-- Summary of sum of rank differences indicated by Friedman test for magnesium concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 37; number of columns= 7. T2= 6.156; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 25.82. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	7.50	23.50	26.00*	8.00	25.50	31.00*
A-2		31.00*	18.50	15.50	18.00	38.50*
A-3			49.50*	15.50	49.00*	7.50
G-4				34.00*	0.50	57.00*
A-5					33.50*	23.00
A-6						56.50*

Table F-9.-- Summary of sum of rank differences indicated by Friedman test for sodium concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 2.956; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 34.85. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	8.00	2.00	33.50	0.50	19.00	33.50
A-2		10.00	25.50	8.50	11.00	41.50*
A-3			35.50*	1.50	21.00	31.50
G-4				34.00	14.50	67.00*
A-5					19.50	33.00
A-6						52.50*

Table F-10.-- Summary of sum of rank differences indicated by Friedman test for ammonium concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 3.714; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 35.37. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	1.50	27.00	15.50	0.00	9.00	59.00*
A-2		28.50	17.00	1.50	7.50	60.50*
A-3			11.50	27.00	36.00*	32.00
G-4				15.50	24.50	43.50*
A-5					9.00	59.00*
A-6						68.00*

Table F-11.-- Summary of sum of rank differences indicated by Friedman test for nitrate concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 4.054; F-value ($\alpha= 0.01$) 3.344; F-value ($\alpha= 0.05$) 2.364. Significant difference value= 35.23. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	1.00	31.50	21.00	6.00	5.50	63.50*
A-2		32.50	22.00	7.00	4.50	64.50*
A-3			10.50	25.50	37.00*	32.00
G-4				15.00	26.50	42.50*
A-5					11.50	57.50*
A-6						69.00*

Table F-12.-- Summary of sum of rank differences indicated by Friedman test for sulfate concentration [Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 37; number of columns= 7. T2= 10.685; F-value ($\alpha= 0.01$) 3.362; F-value ($\alpha= 0.05$) 2.372. Significant difference value= 32.02. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	22.50	77.50*	1.00	28.50	11.50	88.50*
A-2		55.00*	23.50	6.00	11.00	66.00*
A-3			78.50*	49.00*	66.00*	11.00
G-4				29.50	12.50	89.50*
A-5					17.00	60.00*
A-6						77.00*

APPENDIX G: Pairwise differences of sum of ranks from Friedman test for detecting differences in the performance of samplers; deposition of analytes used in the statistical analysis, January 1986 to November 1986.

Table G-1.-- Summary of sum of rank differences indicated by Friedman test for calcium ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 37; number of columns= 7. T2= 4.796; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 30.86. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	11.50	35.50*	7.50	21.00	2.50	59.50*
A-2		24.00	19.00	9.50	9.00	48.00*
A-3			43.00*	14.50	33.00*	24.00
G-4				28.50	10.00	67.00*
A-5					18.50	38.50*
A-6						57.00*

Table G-2.-- Summary of sum of rank differences indicated by Friedman test for chloride ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 37; number of columns= 7. T2= 5.080. F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 32.52. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	9.50	44.00*	12.50	28.00	21.00	39.50*
A-2		34.50*	22.00	18.50	30.50	30.00
A-3			56.50*	16.00	65.00*	4.50
G-4				40.50*	8.50	52.00*
A-5					49.00*	11.50
A-6						60.50*

Table G-3.-- Summary of sum of rank differences indicated by Friedman test for hydrogen ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 2.357. F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 30.86. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	2.50	4.50	28.50*	8.00	21.00	14.00
A-2		7.00	31.00*	10.50	23.50	11.50
A-3			24.00	3.50	16.50	18.50
G-4				20.50	7.50	42.50*
A-5					13.00	22.00
A-6						35.00*

Table G-4.--

Summary of sum of rank differences indicated by Friedman test for potassium ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 39; number of columns= 7. T2= 6.480; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 31.29. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	3.00	44.00*	13.50	34.00*	9.50	73.50*
A-2		47.00*	16.50	37.00*	12.50	76.50*
A-3			30.50	10.00	34.50*	29.50
G-4				20.50	4.00	60.00*
A-5					24.50	39.50*
A-6						64.00*

Table G-5.-- *Summary of sum of rank differences indicated by Friedman test for hydrogen ion deposition* [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 4.568; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 30.86. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	6.00	31.00*	25.00	9.50	29.50*	19.50
A-2		25.00	31.00*	3.50	23.50	25.50
A-3			56.00*	21.50	1.50	50.50*
G-4				34.50*	54.50*	5.50
A-5					20.00	29.00
A-6						49.00*

Table G-6.-- *Summary of sum of rank differences indicated by Friedman test for sodium ion deposition* [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns = 7. T2= 2.879; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 34.88. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	8.00	1.00	33.50	2.50	19.00	32.50
A-2		9.00	25.50	10.50	11.00	40.50*
A-3			34.50	1.50	20.00	31.50
G-4				36.00*	14.50	66.00*
A-5					21.50	30.00
A-6						51.50*

Table G-7.-- Summary of sum of rank differences indicated by Friedman test for ammonium ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 3.714; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 35.37. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	1.50	27.00	15.50	0.00	59.00*	9.00
A-2		28.50	17.00	1.50	60.50*	7.50
A-3			11.50	27.00	32.00	36.00*
G-4				15.50	43.50*	24.50
A-5					59.00*	9.00
A-6						68.00*

Table G-8.-- Summary of sum of rank differences indicated by Friedman test for nitrate ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows= 38; number of columns= 7. T2= 4.054; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 35.23. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	1.00	31.50	21.00	6.00	5.50	63.50*
A-2		32.50	22.00	7.00	4.50	64.50*
A-3			10.50	25.50	37.00*	32.00
G-4				15.00	26.50	42.50*
A-5					11.50	57.50*
A-6						69.00*

Table G-9.-- Summary of sum of rank differences indicated by Friedman test for sulfate ion deposition [Deposition calculated as the product of concentration and amount of precipitation in rain gage. Data collected from 14 January 1986 to 11 November 1986. All samplers included in analysis. Number of rows 37; number of columns= 7. T2= 11.17; F-value ($\alpha= 0.01$) 2.870; F-value ($\alpha= 0.05$) 2.130. Significant difference value= 31.88. * indicates significant difference.]

	Samplers					
	A-2	A-3	G-4	A-5	A-6	V-7
A-1	22.00	77.50*	2.00	28.50	11.50	90.00*
A-2		55.50*	24.00	6.50	10.50	68.00*
A-3			79.50*	49.00*	66.00*	12.50
G-4				30.50	13.50	92.00*
A-5					17.00	61.50*
A-6						78.50*

APPENDIX H: Frequency Distribution of lengths of time that sampler is
open

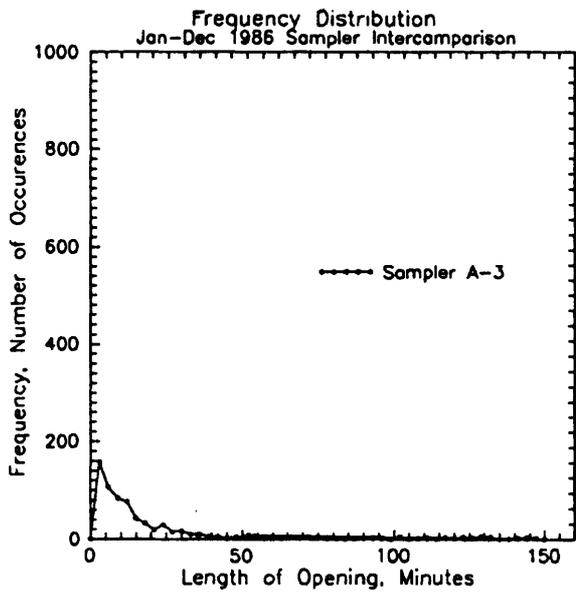
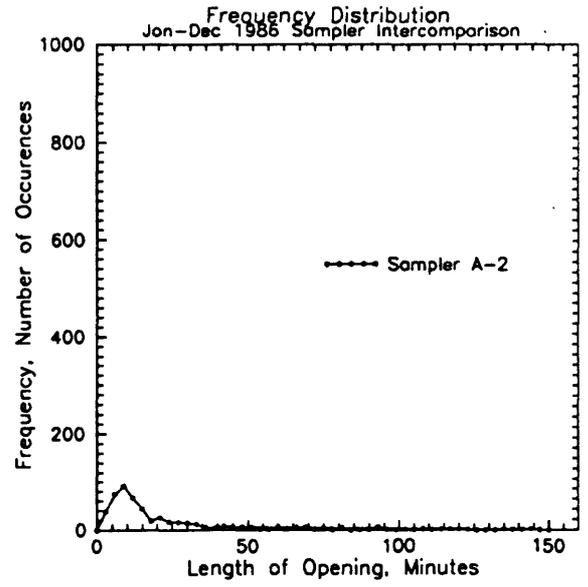
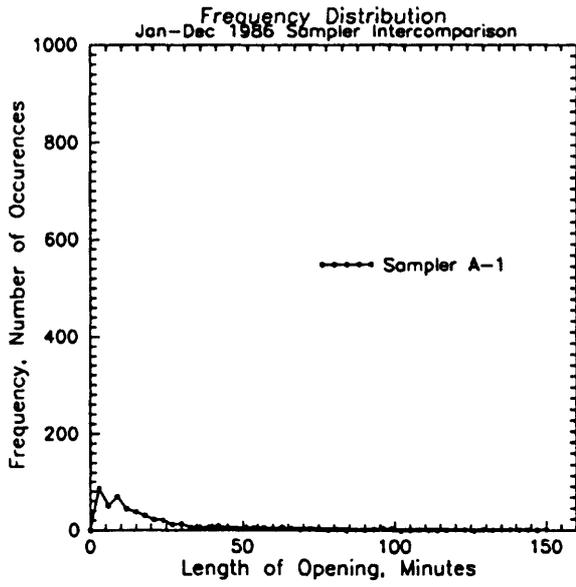


Figure H-1.-- Frequency Distributions for length of time that sampler is open:

Sampler A-1
Sampler A-2
Sampler A-3

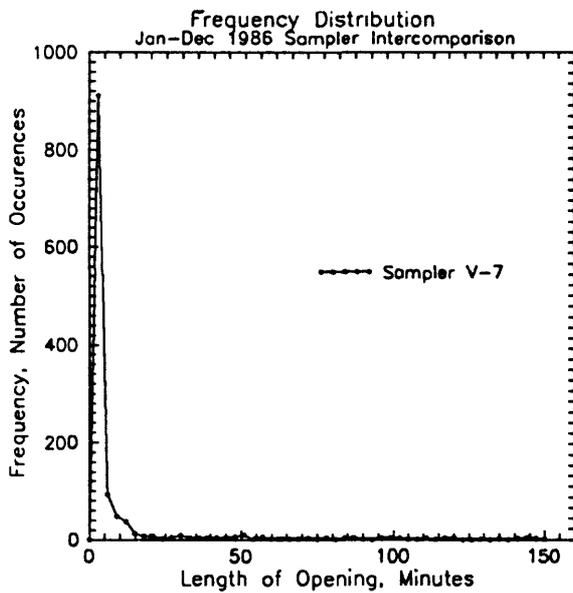
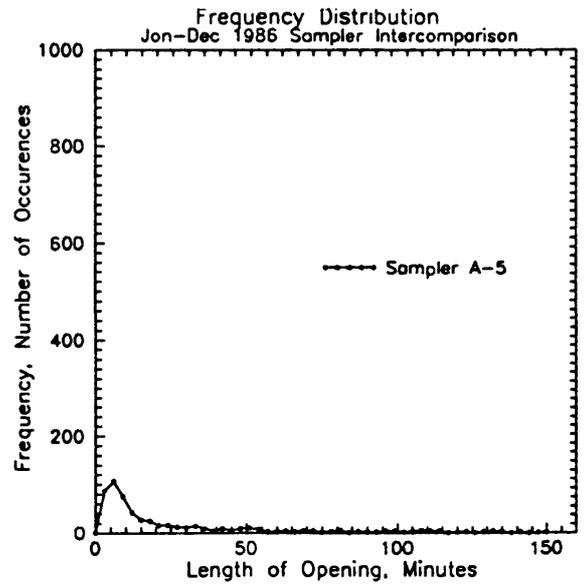
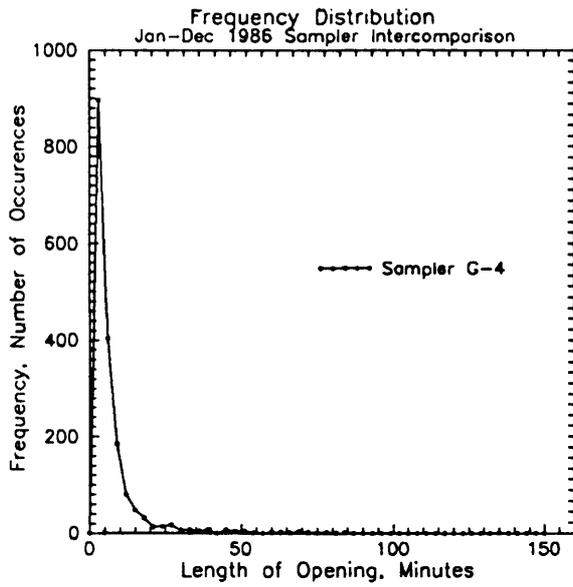


Figure H-2.-- Frequency Distributions for length of time that sampler is open:

- Sampler G-4
- Sampler A-5
- Sampler V-7

APPENDIX I: Cumulative frequency distribution for length of time that sampler is open.

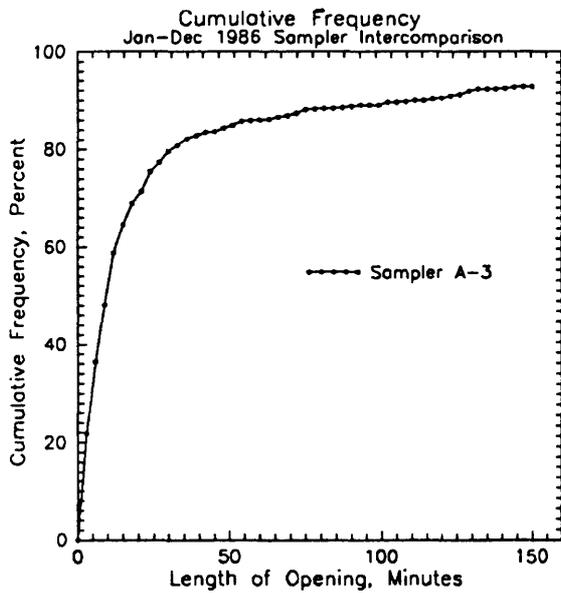
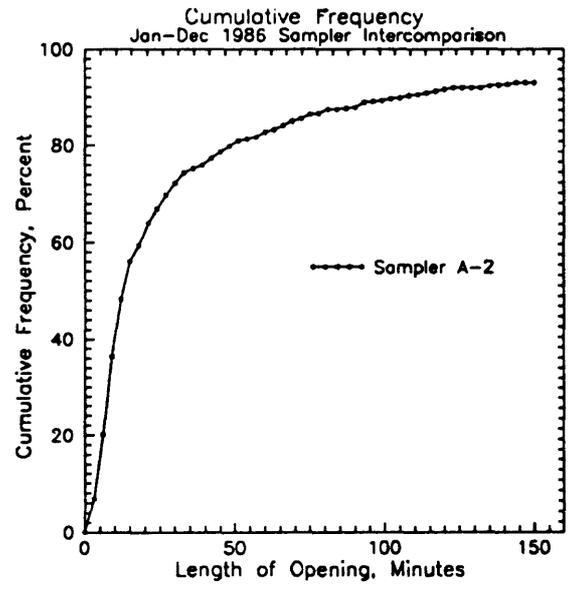
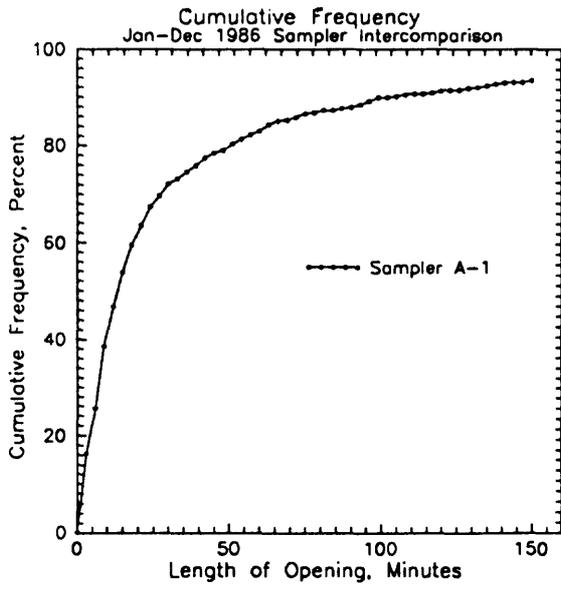


Figure I-1.--

Percent cumulative frequency distributions for length of time that sampler is open:

- Sampler A-1
- Sampler A-2
- Sampler A-3

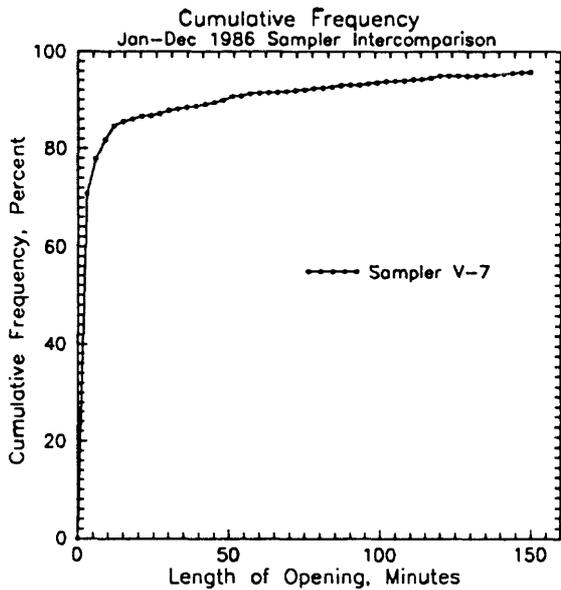
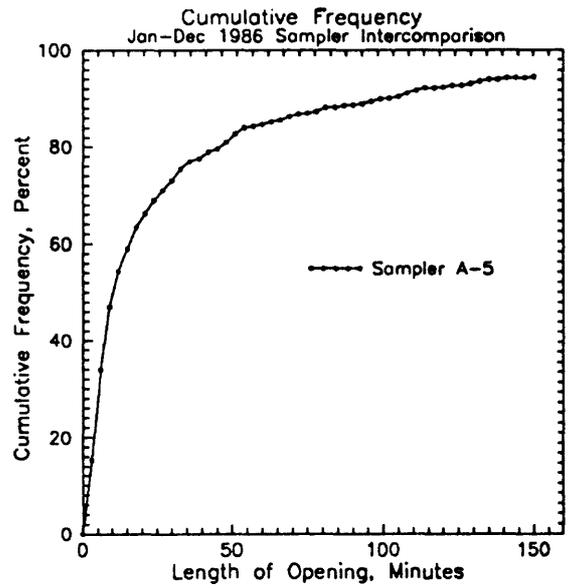
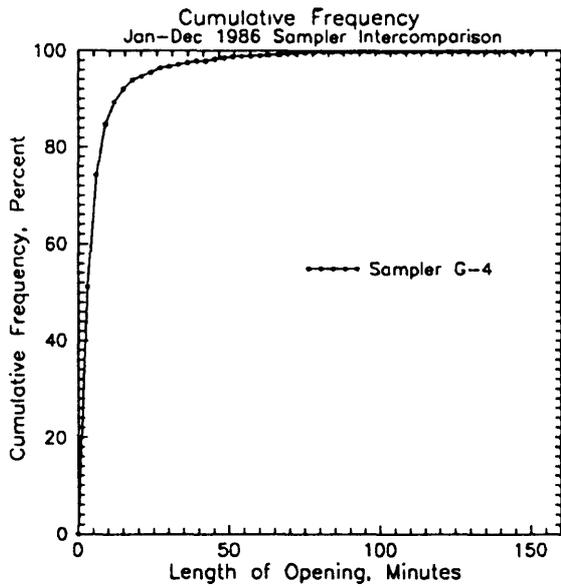


Figure I-2.-- Percent cumulative frequency distributions for length of time that sampler is open:

- Sampler G-4
- Sampler A-5
- Sampler V-7